Science Conspectus

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VOL. IV 1914 No. 1

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

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THE AERONAUTICAL ENGINEER

DEVELOPMENT OF THE MODERN AIRSHIP DUE TO ENGINEERING RESEARCH WHICH IS NOW BEING CARRIED ON VIGOROUSLY IN GREAT BRITAIN AND ON THE CONTINENT

BY JEROME C. HUNSAKER

THE early history of aircraft is essentially a record of the contributions to knowledge of scientists and engineers, interspersed at intervals with the records of performances of daring aëronauts who were more in the public eye. For example, the development of the modern airship began with the discovery of hydrogen by the chemist Cavendish in 1766. In 1768 Cavallo, the physicist, showed hydrogen soap bubbles to the Royal Society. In 1783 Professor Charles of Paris constructed and made a flight in the first hydrogen balloon.

The dirigible balloon or modern airship was developed by the engineers Giffard, General Meusnier, Tissandier, Captain Renard, and the naval architect Depuy de Lôme. Their efforts were not crowned with success because at that time the gasolene motor had not been perfected. The modern airship is the direct product of the application of the gasolene motor to the early dirigibles. The non-rigid type was perfected in France by the engineers Santos Dumont, Lebaudy, and Surcouf; and in Germany by Major Gross, Major von Parseval, and the engineers Basenach and Reidinger. At the same time the rigid type, conceived by Schwartz, was successfully developed by Count Zeppelin. All these are men of superior engineering training.

Similarly the aëroplane can be traced from the experiments of Sir George Caley who in 1810 analyzed the mechanics of flight and conducted experiments with gliders. The development of the modern aëroplane can be outlined by means of the following table:

1866	Wenham	First monoplane glider.
1868	Stringfellow	Steam driven model aëroplane.
1879	Tatin	Compressed air driven model aëroplane.
1891	Hargrave	Box kite, with remarkable stability.
1893	Phillips	First wind tunnel research.
1895	Lilienthal	Long distance gliding.
1896	Langley	Gasolene driven model aëroplane.

These men were all engineers, and each one contributed something of value to our knowledge of dynamic flight. The application of the principles they had discovered and enunciated resulted in the invention of the first aëroplane. As in the case of the dirigible balloon, the efforts of the pioneers were unsuccessful until the introduction of the gasolene motor. The pioneers whose work was most valuable were, to name a few of them, Maxim, Ader, Chanute, Ferber—all men of engineering training. The Wright brothers, to whom we owe the first practical aëroplane, had the assistance of Mr. Chanute and Mr. Huffaker,

who had been Professor Langley's assistant.

At the present time our knowledge of aëronautics is being broadened by the scientific research of many men in the universities and testing laboratories of Europe.

Considering the importance to the art of the trained engineer, it is only a step farther to the time when this art will have developed into an industry which will demand engineers especially trained to handle its problems. At the present time such engineers as are employed on aëronautical work are in a sense self-taught. They were first engineers, and in time came to be qualified as aëronautical engineers. With the growth of an aëronautical industry abroad has recently come a demand for technically trained men, aëronautical engineers, and the technical schools are beginning to supply this demand.

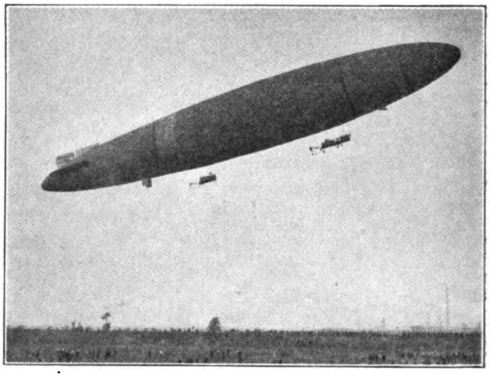
However, before considering what steps are being taken in this direction, it may be well to consider the status of aëronautics at the present time.

Commercially, the airship as developed in France and Germany has met with small success on account of the high cost of operation, frequency of accident, and small carrying capacity. It is true that certain passenger ventures have seemed to prosper, but they have been subsidized by the state or a society interested in educating the public. In no way has the airship been used as a transportation facility for commercial purposes.

The aëroplane in the days of a fascinated public in Europe, as here at home, offered a great attraction for the showman, and exhibitions and races were largely attended. Large prizes were offered by enthusiastic men. Now the public has had its opportunity to see the flying machine and it inquires, "Of what use is it?" Commercially, due to unreliability, small carrying power, and expense, the aëroplane has found no application except a recent attempt to carry the mails across the Sahara desert.

From the point of view of the sportsman, the airship is too costly and the aëroplane too dangerous to have a large following. There is a chance, however, that the flying boat recently brought out by Curtiss in America may appeal to sportsmen.

The naval and military interest in aircraft contrasts strongly with the scepticism of the general public. It can fairly be said that the rapid development of all types of aircraft in the past few years has been due almost wholly to the moral and financial encouragement of the great military powers of Europe. We in America are not a great military power and we have no vital interest in developing aircraft so long as our possible enemies lie beyond the probable radius of action of such craft. It is for this reason, no



The Schüette-Lanz, German dirigible with rigid frame of wood

doubt, that progress in aëronautics during the past five years has been almost entirely due to the enterprise of foreigners.

Nevertheless, we now have vulnerable outposts at Panama and the Philippines, and there is already an awakening interest in military aëronautics due to the Mexican problem.

At the present time, from consideration of the same problem of national defense, England, Germany, France, Russia, Italy, and Austria have decided to maintain aircraft for war use. It is hardly possible that these governments should be united in a common mistake in policy.

It appears to be the general opinion

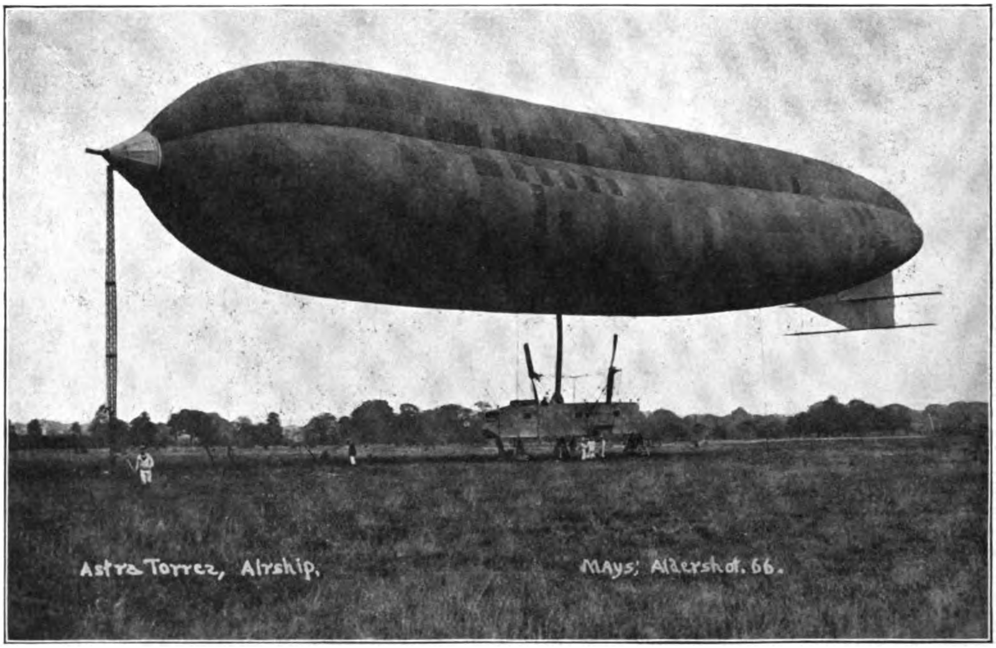
Schwaben, German Zeppelin which carried over 4,000 passengers in four months

that the aëroplane is suited for scouting operations in which the flight out and return can be made in daylight and within a radius of 150 to 200 miles. It is necessary for the aëroplane to return to its base to report its observations in the present stage of wireless telegraphy. The Italian experience with aëroplanes during the recent war with Tripoli led to the conclusion that an aëroplane must operate at an altitude of at least 3,000 feet in order to be safe from rifle fire. At such an altitude the high speed of the aëroplane offers little hindrance to careful observation of the ground, and it is possible to distinguish bodies of troops, their direction of march, presence or absence of bridges, condition of railroad tracks, and the general arrangment of camps. It is not possible to distinguish troops which are deployed or which are marching through wooded country.

It has been urged that aëroplanes may be used offensively to drop bombs upon hostile troops, but due to the fact that an aëroplane can operate only in daylight and at an altitude greater than 3,000 feet, the chance of making a hit with a bomb dropped from such a height is very small. At the same time, the radius of action of an aëroplane is so small that it seems unwise to sacrifice weight devoted to fuel storage to a supply of bombs. Furthermore, the small bombs that can be carried by an aëroplane are not likely to have a very destructive effect.

The use of the machine gun from an aëroplane will probably be of service against the enemy's dirigible balloons, and it seems to be the general opinion that the offensive use of aëroplanes will be confined to action against the enemy's aircraft.

The hydro-aëroplane and flying boat appear to be well adapted for scouting over inland and coastal waters, and the recent development of the flying boat renders it suitable for scouting at sea in



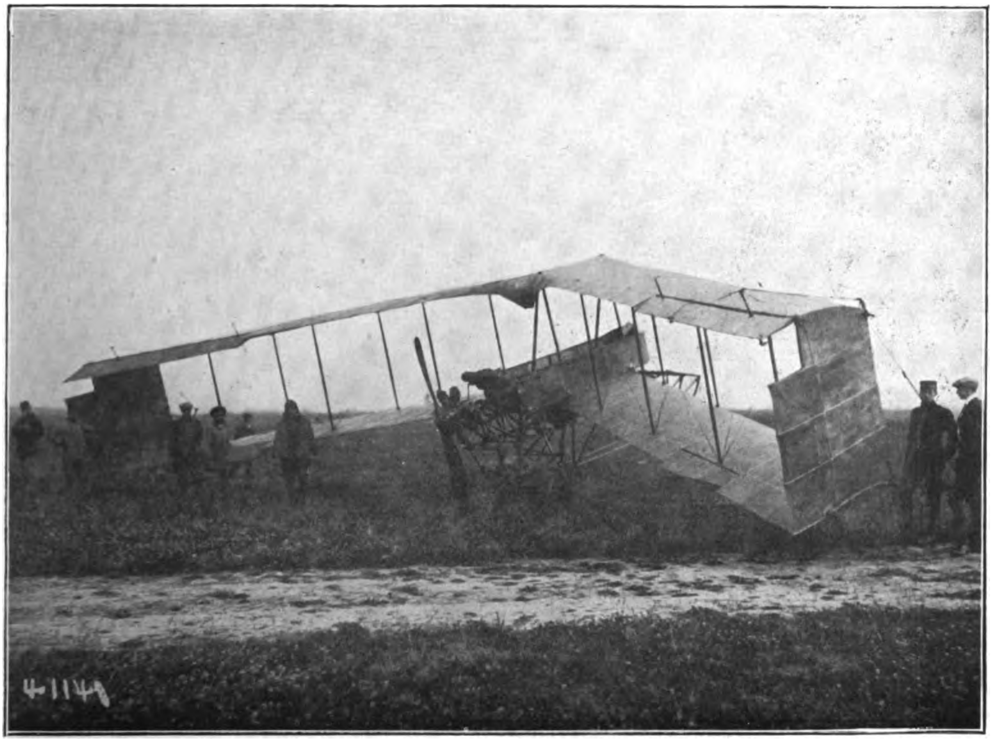
Astra-Torres, non-rigid dirigible (French), moored to a mast at British Army Aviation Field, Aldershot

conjunction with the fleet. The flying boat may be carried aboard a battleship and launched from a catapult or from the water alongside. It can be expected to conduct scouting operations over a radius of 100 miles from the ship, and in ordinary weather may land on the lee side of the ship and be hoisted aboard. At the present time the principal defect of the flying boat is its limited radius of action due to the weight that must be sacrificed for the hull. Furthermore, the flying boat is unable to land upon a rough sea, so that the days it may be used are limited by weather conditions.

For both land and ocean scouting, it has been found necessary to carry an observer in addition to the pilot. It is not considered satisfactory to require the pilot to do more than operate his machine. In aëroplanes which are expected to make long trips the controls are duplicated in such a manner that the pilot and the observer may relieve one another.

The airship in time of war or immediately preceding the outbreak of war will probably be used for long distance strategical reconnaissance, for which service the aëroplane is not satisfactory. For instance, the radius of action of the non-rigid airship may be made as high as 1,000 miles. The airship can travel at night and can be fitted with a wireless telegraph both for sending and receiving messages. If the speed of such a dirigible be above 45 miles per hour, it can probably be operated 85 days out of 100 in central Europe. The large non-rigid dirigibles may have a radius from 1,500 to 2,000 miles and have a correspondingly greater value for long distance scouting, but at the same time require extensive sheds for housing. On the other hand, the non-rigid ships may be moored by the nose to a mast in an open field in good weather, and in case of storm the non-rigid envelope may be deflated and so save the ship from destruction. The non-rigid ship can be transported by automobile trucks or by railroad and inflated in the field from a portable gas generator.

For naval purposes the non-rigid airship seems well adapted for operations

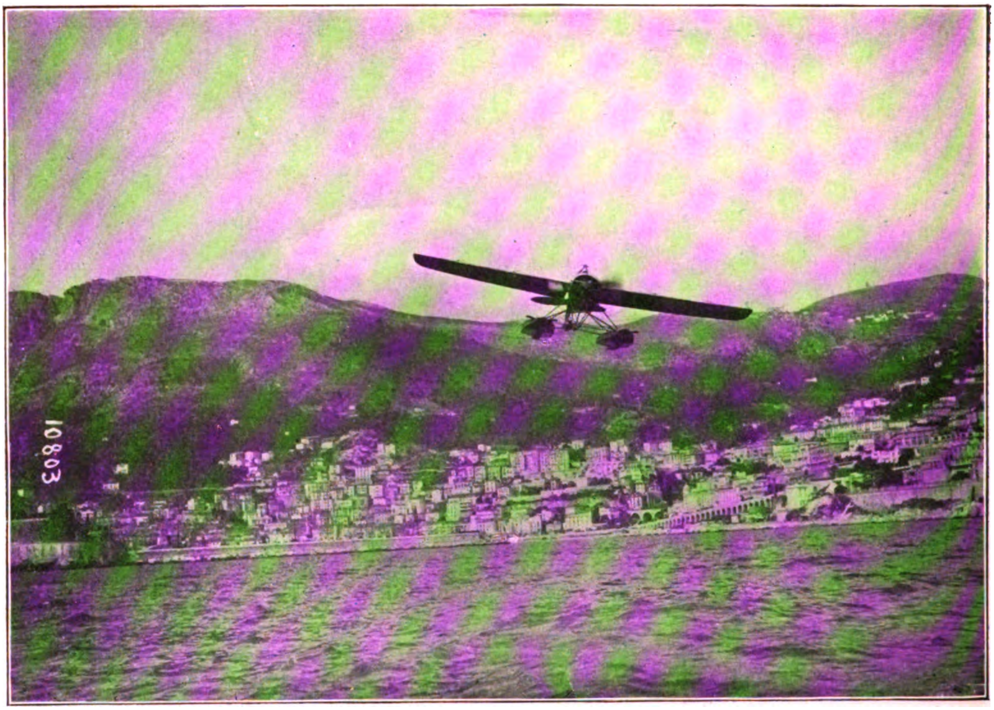


Dunne Biplane (England), designed for inherent stability

over seas. The dirigible may be carried aboard a transport or supply ship to the advance base that has been seized by the fleet and sent out to determine the location and strength of the enemy's fleet.

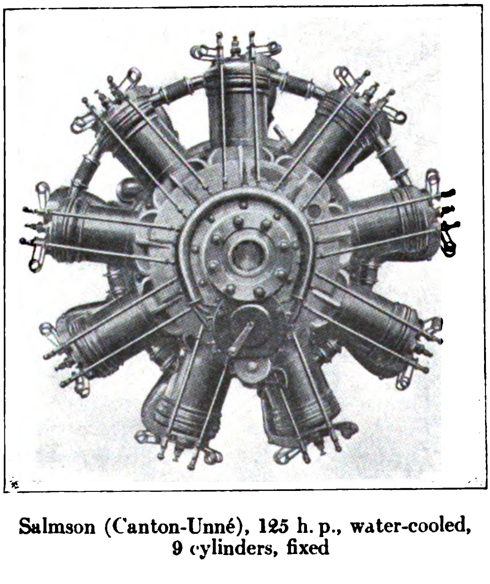
The dirigible both of the rigid and non-rigid types may play a part in offensive operations in time of war, but it is hardly likely that a commander would risk having one of his dirigibles destroyed in an attempt to drop bombs upon an enemy's position. The dirigible presents such a large target that by day it is considered necessary to remain at an altitude of at least 5,000 feet to be safe from gun fire. From such a height bomb dropping would be very difficult. However, at night when the dirigible's movements are hidden such a ship might well pass low over an enemy's camp, dock yard, arsenal or magazine and by dropping high explosives or incendiary bombs effect considerable damage. A modern dirigible can be provided with ten 100-pound torpedoes filled with high explosive. For offensive operations against armored vessels it is not likely that the surface explosion produced by such a torpedo striking a deck or turret top would produce any serious damage. However, the moral effect of dropping bombs at night into an enemy's camp or fortress is difficult to estimate.

The tactical uses of aircraft in war cannot be discussed fully here. The experience that European nations gain from their manœuvres is kept profoundly secret. On the other hand the conclusions that such nations reach as to the value of aircraft are made apparent by their increased activity in building them. For example, the past summer naval manœuvres of the British fleet in the North Sea have been followed by great activity on the part of the Admiralty in purchasing French, German, and Italian dirigibles and in large orders to British aëroplane builders. The reasons



Nieuport Monoplane fitted with hydroplane floats

upon which this decision to establish an aërial fleet has been reached are unknown to us, but they must have been sufficient.



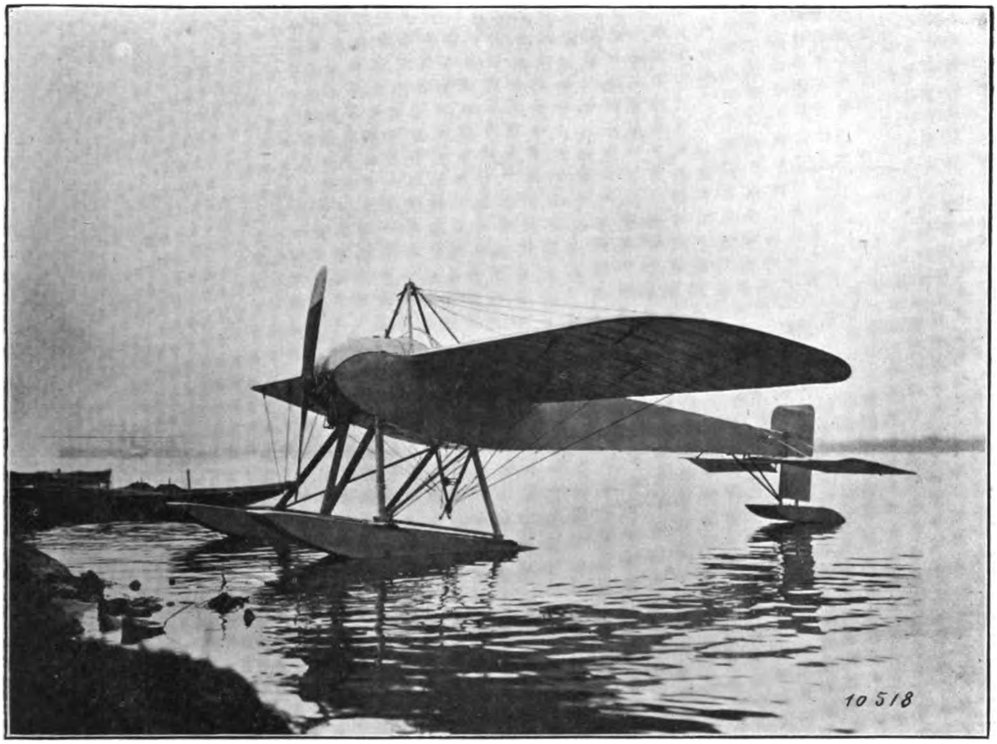
Salmson (Canton-Unné), 125 h. p., water-cooled, 9 cylinders, fixed

The building of aircraft is a recognized industry in France, Germany and England. The French army intends to have 1,000 aëroplanes in service as soon as a sufficient number of men can be trained as pilots. The Farman factory alone is turning out one complete aëroplane a day. In England the Royal Aircraft Factory employs 750 men working on experimental machines exclusively. In Germany one airship factory expects to turn out five ships in the coming year.

With all this activity it is natural to ask who is directing it. In nearly every case it is the engineer who is qualified in aëronautics.

The growth of the aircraft industry in the United States can be forced by the policy of the government or it can be the natural result of a radical improvement in the machines tending to make them more trustworthy.

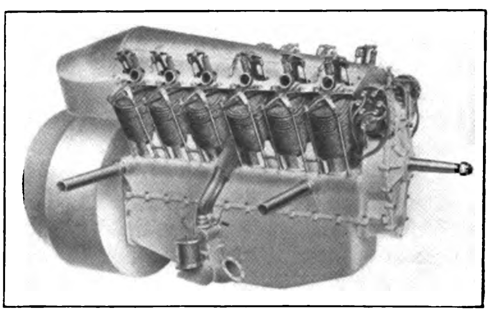
A part of the great sums of money spent for military aëronautics abroad has found its way into experimental and engineer-



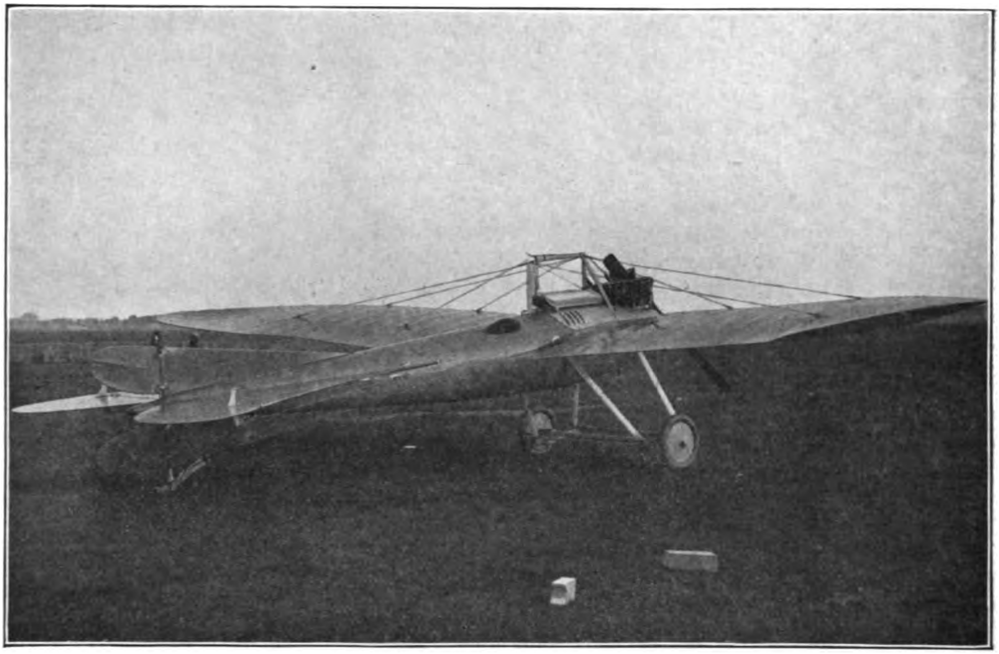
Borel Monoplane, showing wing stays of wire cable running to upper and lower king posts

ing research with most satisfactory results. Flying is today safer than a year ago, and infinitely safer than four years ago. In the earlier days of the art, structural failures were frequent, but from a better understanding of the forces involved an engineer can now provide an adequate factor of safety in his design. The stability of aëroplanes is better understood, and though the non-capsizable aëroplane has not yet been produced it is reasonable to suppose that the future will bring new light on this subject. Aëroplane surfaces are more efficient, and motors more powerful and more reliable. The speed of 40 miles an hour reached by the first Wright aëroplane has been increased to over 120 miles an hour in the Deperdussin monoplane of 1913. At the same time the radius of action of the earlier aëroplanes of about 50 miles has been increased to 700 miles in the modern French single seater monoplane. Similar improvements in speed and radius of action have been effected in dirigibles until we have the modern French and German dirigibles capable of a speed in excess of 50 miles an hour.

At the present time the most successful aëronautical research is being prosecuted in England at the National Physical Laboratory on small models and



Renault, 90 h. p., water-cooled, 12 cylinders



Albatross Monoplane

at the Royal Aircraft Factory on full sized machines. These two institutions are directed and their efforts coördinated by a committee of eminent scientists and engineers, headed by the physicist Lord Rayleigh. The results of their experiments have produced the famous military biplane known as B E 2, in which a speed in the air of 80 miles an hour is combined with a speed in landing and starting below 37 miles an hour. Its stability is excellent, and its construction is rugged and at the same time light and elastic.

At Northampton Institute in London courses are given in aëronautical engineering, and a wind tunnel is installed for the instruction of students.

In France the foremost civil engineer, M. Gustav Eiffel, has retired from the practice of his profession and is devoting the remainder of his life to aëronautical research. His private laboratory has the most powerful wind tunnel in the world with an 80-mile-an-hour blast of wind. Inventions and new designs are tested by him without fee on the sole condition that the results shall be published for the benefit of the aëronautical industry of France.

The French army maintains an experimental laboratory at Chalais-Meudon, and the University of Paris has an extensive "aëro-technic" laboratory at St. Cyr, including a whirling arm and wind tunnel for model work and a dynamometer car electrically propelled on a track upon which full sized aëroplanes or propellers may be mounted for study.

The "École Superieure Aëronautique" has been founded to educate aëronautical engineers. A one-year course of a post-graduate character is given by a faculty including some of the most able men of the Polytechnique. Only graduates of a first grade engineering school are admitted. Forty men completed the the course in 1912–1913.

In Germany, the University of Göttingen has a well-equipped aëronautical laboratory conducted by Doctor Prandtl, the head of the department of mechanics. Candidates for the degree of doctor of

philosophy are admitted as research assistants.

The technical high schools of Berlin and Aachen have provided aëronautical laboratories and offer courses in aëronautical engineering to students who have completed the required courses in mathematics and mechanics.

It is apparent that the future of aëronautics depends upon the results of research work. The elements of flight have been discovered and it is now a problem of perfecting the first crude machines. It is the history of human achievement that such perfection has always been

Ten Blériot Military Monoplanes dismounted for shipment to a French frontier post

brought about. From a military point of view there appears to be a race for supremacy in the air by the great European powers. The race cannot be won by the mere multiplication of existing types because the production by one country of a type of aircraft of marked superiority to any now existing will immediately render obsolete the entire aërial fleets of her rivals. The race, therefore, is not only between factories and constructors, but also between the designers and the staffs of the research laboratories.

OUR EUROPEAN POPULATION

In the *Journal* of the Washington Academy of Sciences for January 4, 1914, occurs a brief résumé of an interesting talk by Dr. Daniel Folkmar before the Anthropological Society of Washington on "Some Results of the First Census of European Races in the United States." If the total white population of the United States in 1910, about 82 millions, be taken as 100 per cent., the native stock constitutes 60.5 per cent. The "foreign stock" made up thus 39.5 per cent. of our white population in 1910. Of this, 27.1 per cent. came from northwestern Europe, *i. e.*, English, Germans, Scandinavians and North French while less than 13 per cent. came from southern and eastern Europe, mostly Poles, Yiddish Hebrews, Italians, Greeks and Bulgarians. The five linguistic races contributing most are, in order, English, German, Italian, Polish, Yiddish; the English furnishing about 10 millions, the German 7 millions and none of the others equalling one quarter of the German.

H. W. S.

VOLCANIC ERUPTIONS AFFECT CLIMATE

Dr. C. G. Abbott, director of the Astrophysical Observatory of the Smithsonian Institution, advances the theory that volcanic explosions affect the climate directly. It is certain that an agency capable of sending great clouds of dust twenty miles high in the air, to be distributed by the winds all over the world, and to remain in suspension for months, causing the decrease of the direct radiation of the sun by as much as 20 per cent., is a climatic influence not to be ignored.

While making measurements of the quantity of heat coming from the sun at Algeria two years ago, Dr. Abbott noted streaks resembling smoke lying along the horizon, which, in the course of a day or so, developed into such a haze that work was practically impossible. This condition lasted for nearly three months.

SUGAR AS AN ANTISEPTIC

Sugar as a surgical antiseptic has been recommended by an eminent German surgeon; although all saccharine substances are good, pure cane or beet sugar is best. It is said that it is not injurious to the blood, and is a better preventive of putrefaction and contamination by microbes than ordinary medical antiseptics.

THE VITAMINES

THE RECOGNITION OF ESSENTIAL CONSTITUENTS OF THE DIET HITHERTO UNCLASSIFIED — DEFICIENCY DISEASES

BY PERCY G. STILES

If a physiologist is asked what are the requisites of a normal diet he will probably reply somewhat as follows: First, it must represent an adequate quantity of available potential energy, not less than 2,000 calories for the average human adult. Second, it must contain protein (nitrogenous) food sufficient to compensate for the unavoidable daily loss of similar material from the body. Third, it must be palatable and digestible, making due allowance for personal idiosyncrasy. He will very probably content himself with these three postulates.

If the inquiry is pressed the man of science may recollect that another necessary condition of successful nutrition is a proper supply of the inorganic or mineral elements in sufficiently varied assortment. The tissues cannot be developed or maintained without chlorides, phosphates, and other saline contributions. The need for substances of this class is more urgent during the period of growth than later but it always continues to exist. A similar statement may be made with reference to the protein of the ration; this, too, must be furnished in relative abundance and varied form during the growth of the subject and may be reduced when full stature has been reached. Mendel has shown that kind as well as quantity must be considered when protein is chosen for experimental nutrition of an animal. Proteins from certain sources suffice for maintenance only and not to minister to growth.

With the accumulation of physiological data during the past few years it has become increasingly apparent that there may be criteria for the adequacy of a diet not included in the list just given. There are now known to be organic compounds other than proteins, small quantities of which are absolutely essential to normal growth and even to continued health in the adult condition. The name of Vitamines has been proposed for all such substances. The word is well chosen in view of its root-meaning; an amine is a nitrogenous compound of a certain type and a vitamine is obviously such a compound with the added distinction of being necessary to life. Casimir Funk of London has been one of the foremost contributors to the development of this conception and a valuable summary of his own work and his judgment of the work of others may be found in the *Ergebnisse der Physiologie*, Vol. XIII, pp. 124–205. (Wiesbaden, 1913.) This article is the chief source of the present abstract.

A class of serious disorders has long been known in which failure of nutrition could be named as the cardinal fact in the case and in which it has somewhat vaguely been assumed that the diet must be at fault. The most familiar disturbance of this class, at least to the general reader, has probably been scurvy. The chronicles of exploring expeditions in polar regions have contained many harrowing accounts of the ravages of this disease. It has usually been associated with the consumption of a monotonous ration, deficient in fresh vegetables and often containing a great deal of salted or canned food. Certain supplementary articles of diet, such as onions, limes, and lemons, have been credited with some power to ward off or at least to mitigate the trouble and they have been spoken of as antiscorbutics.

The victims of scurvy suffer from severe prostration, loosening of the teeth, intense

soreness of the gums, friability of the bones, and a tendency to hæmorrhage partly due to a loss of the coagulating property of the blood. Those who have read the classic journals of Doctor Kane will recall the distressing situation on board his ship at the end of the Arctic winter and the commander's device to cheer his helpless men in the forecastle by setting up a mirror to bring into their midst the first sunbeam from the southern horizon. Scurvy has become less common with better supplies of food available for such parties but it has been noted within a very few years.

Another disorder which has lately attracted much attention is beri-beri, It has its recognized centre in the East, particularly in Japan, China, Indo-China, and the Philippines. Its occurrence in Newfoundland has recently been reported. Those who suffer from beri-beri are usually the very poor and, in the Orient at least, they are people who live chiefly upon rice. In Japan the disease has been nearly eliminated from the army and navy by providing more liberal and varied rations. The symptoms are complex but they are in general such as can be referred to the impairment of the nerves which is known to be the most prominent physical change. There is a period of declining weight and strength and this is followed by the development of a "multiple neuritis" with partial paralysis in both the motor and the sensory realms.

Various theories have been held with regard to beri-beri. It has been believed to be an infectious disease because it so often affects a large number of people who are closely associated, as in a prison, a ship, or a laborers' camp. The fact was formerly overlooked that such companies share the same diet and that their trouble may well be due to that source. This is now accepted as proved. But when the decision is reached that something must be wrong with the food there are still two possible views to be considered. Is the diet positively poisonous or is it merely insufficient? This question has been asked both with reference to scurvy and to beri-beri. It is not easy to answer it in such a way as to meet all objections. Nevertheless, the tendency is toward the conclusion that it is the inadequacy rather than the toxic nature of the food which is to be held responsible in these and perhaps in other cases.

It is proposed to call such failures of nutrition "deficiency diseases." It is assumed that the lack is of one or more of the specific substances already termed vitamines. The evidence in support of such a conception is especially convincing in the case of beri-beri. As long ago as 1897 it was discovered that rice which has been "polished"—that is, deprived of its pericarp or immediate husk—has a tendency to induce beri-beri and that the inclusion of the pericarp makes it entirely wholesome. It has been possible to confirm this in a striking manner by experiments on birds. If a fowl or a pigeon is restricted to polished rice as a diet it soon refuses to eat. If forced feeding is then resorted to it soon becomes pitiably weak and cannot long survive. The partial feeding is thus as surely destructive as absolute starvation. Post-mortem study of such birds shows marked degeneration of the nerves. The service of the pericarp may be conceived of in either of two ways. The polished rice may contain an active poison for which the husk provides a natural antidote. The alternative is that the pericarp furnishes a necessary constituent of the nerve tissue, a vitamine, for want of which the nerve-fibres deteriorate. How hard it is to choose between these two views has already been suggested.

Funk has been successful in his patient endeavor to isolate the vitamine the lack of which causes beri-beri. He has obtained from the pericarp of rice a number of fractions, only one of which has the remedial property. This appears to be a definite organic body to which a formula can be assigned. It contains nitrogen but not phosphorus, an element which earlier workers had believed to be concerned. The vitamine can be separated from other foods than rice. Various animal tissues yield it and so do certain vegetables. Any kind of food which contains the vitamine may be

used to supplement a ration of polished rice with the result that it becomes sufficient for the maintenance of the animal. Yolk of egg and yeast are said to have the curative power in the highest degree.

It is interesting to follow Funk's conjectures as to the systemic effects of the withholding of the invaluable vitamine. We know that in starvation the organs which cannot be spared are sustained at the expense of others. The heart and the nervous system have been found to keep their full weight to the last while tissues which are less necessary to the continuance of life are greatly reduced. Even the bones are levied upon to the extent of one sixth of their mass. We may expect to see the same principle illustrated in the partial starvation which is at the root of any deficiency disease.

So in beri-beri it may be supposed that the vitamine which is absolutely essential to the normal nervous system is not at first confined to that part of the body. The feeding experiments have given evidence that it is present in the muscles though rather scantily. It is to be expected that in the event of failure of a supply direct from the diet the muscles will be made to surrender their store of the vitamine to replace that which has been destroyed in the nervous tissues. If we are to think that the vitamine is essential to the muscles as well as to the nerves we shall anticipate that its withdrawal will result in a disintegration of the muscle protoplasm quite out of proportion to the small amount of vitamine yielded to the preferred creditor. So for a while there will be loss of weight and strength but no marked nervous symptoms because the nerves are being kept in condition at the cost of a remorseless sacrifice of the other tissues. When the internal supply ceases to be sufficient the acute nervous effects are at once developed.

It is the opinion of Funk that both beri-beri and scurvy are prevented by the liberal use of potatoes. Before this vegetable was introduced into Europe there were severe epidemics which are believed to have been outbreaks of scurvy. The suggestion that the potato should now be added to the food-supply of the eastern countries in which beri-beri is prevalent seems a wise one. But the fact is to be emphasized that almost any diet is free from objection if it is reasonably varied. It is where poverty or some other compulsion is operative that nutritional disasters are likely.

The condition of the body in scurvy is quite different from that in beri-beri and the missing compounds are probably somewhat unlike. Some articles of diet may protect against both; some may be specific for only one. Allied with scurvy are the disorders called ship beri-beri, infantile scurvy (Barlow's disease), and the experimental scurvies which can be produced in animals by limiting the intake to a few foods. Still other pathological states may be found to have a more or less similar basis. An attempt has been made to justify the claim that pellagra is a deficiency disease but this is strongly contested. Abnormalities of early development such as rachitis (rickets) and, perhaps, later perversions of growth such as cancer may be connected with the lack of certain chemical constituents in the income of the body. At this point it may be in order to say that the diet itself may conceivably be ideal and yet there may be a failure to utilize the vitamines offered either because of a failure to absorb them or because of their premature decomposition in the alimentary tract.

A few years ago Crichton-Browne, an English authority, in passing an unfavorable judgment upon the dietetic standards of Chittenden and others called attention to the fact that the diet approved by them seemed to correspond closely with that of the very poor. The comparison was based upon fuel value and protein content. It is now possible to modify the statement that the two are precisely equivalent. The low diet of the New Haven school is an inclusive one while that of the poor is of limited variety. A supply of the requisite minor bodies—vitamines, if we adopt the term—is much more surely to be relied on in the first case.

Bunge, the Austrian physiologist,

pointed out in 1901 that sugar is an unnatural food, in that it has been refined to the exclusion of all compounds but saccharose. Foods which are not deliberately prepared by industrial or domestic processes are always mixtures, however much one constituent may predominate. The teaching of Sylvester Graham in the first half of the nineteenth century that the foods offered by nature should not be separated into their ingredients but taken in their entirety is frequently reëchoed in our own day. In the light of studies like those of Funk it is apparent that there is a certain foundation for the idea that foods may be "denatured" either by discarding valuable fractions or by modes of preparation which destroy essential compounds. The fear that disturbances of nutrition from such causes threaten the American people as a whole may be dismissed, but it is interesting to have a new insight into a matter which under certain conditions becomes of pressing importance.

MAN'S PEDIGREE

In his paper on The Evolution of Man Prof. G. Elliot Smith says:—

No one who is familiar with the anatomy of man and the apes can refuse to admit that no hypothesis other than that of close kinship affords a reasonable or creditable explanation of the extraordinarily exact identity of structure that obtains in most parts of the bodies of man and the gorilla. To deny the validity of this evidence of near kinship is tantamount to a confession of the utter uselessness of the facts of comparative anatomy as indications of genetic relationships, and a reversion to the obscurantism of the dark ages of biology. But if anyone still harbors an honest doubt in the face of this overwhelming testimony from mere structure, the reactions of the blood will confirm the teaching of anatomy; and the susceptibility of the anthropoid apes to the infection of human diseases, from which other apes and mammals in general are immune, should complete and clinch the proof for all who are willing to be convinced.

Nor can anyone who, with an open mind, applies similar tests to the gibbon refuse to admit that it is a true, if very primitive, anthropoid ape, nearly related to the common ancestor of man, the gorilla, and the chimpanzee. Moreover its structure reveals indubitable evidence of its derivation from some primitive Old World or catarrhine monkey akin to the ancestor of the langur, the sacred monkey of India. It is equally certain that the catarrhine apes were derived from some primitive platyrrhine ape; the other, less modified descendants of which we recognize in the South American monkeys of the present day; and that the common ancestor of all these primates was a lemuroid nearly akin to the curious little spectral tarsier which still hunts the forests of Borneo, Java, and the neighboring islands, and awakens in the minds of the peoples of those lands a superstitious dread—a sort of instinctive horror of the sight of the ghost-like representative of their first primate ancestor.

This much of man's pedigree will I think be admitted by the great majority of zoologists who are familiar with the facts; but I believe we can push the line of ancestry still further back, beyond the most primitive primate into Haeckel's suborder Menotyphla, which most zoologists regard as constituting two families of insectivora. I need not stop to give the evidence for this opinion, for most of the data and arguments in support of it have recently been summarized most excellently by Dr. W. K. Gregory.

BY WIRELESS 6000 MILES

Communication was recently held between the wireless station at Nauen, Ger., and one at Windhoek, Cape of Good Hope, South Africa. The messages that passed were clear and distinct. The distance between Nauen and Windhoek is approximately six thousand miles. At various times there have been reports or messages traveling six thousand miles of more, but very few, if any, of these have been direct communications.

THE QUEEN CHARLOTTE ISLANDS.[1]

DESCRIPTION OF THESE LITTLE-KNOWN ISLANDS AND OF THE ORIGINAL INHABITANTS, THE HAIDA INDIANS—EVENTFUL GEOLOGIC CAREER OF THE GROUP

BY J. D. MACKENZIE

INTRODUCTION

THE Queen Charlotte Islands, comprising one of the remote districts of Canada, are an interesting and little-known group. During the past summer the writer spent three months on these islands, with a party engaged in field work for the Geological Survey of Canada, and some of the results of our investigations are here set forth.

The Queen Charlotte Group, stretching from 52° to 54° 15′ north latitude, and from 131° to 133° west longitude is situated in the North Pacific Ocean, 140 miles north of Vancouver Island, and about 40 miles south of the southern extremity of Alaska. The islands form a slightly curved triangle, shaped like the truncated end of a crescent convex toward the Pacific, with its apex pointing south. The length of the triangle in a northwesterly direction is about 190 miles, and the width of its base, the northern coast of Graham Island, is 60 miles.

The Grand Trunk Pacific Steamship Company maintains a regular passenger and freight service between Victoria, Vancouver, Prince Rupert, and the Queen Charlotte Islands. The boats are comfortable and well fitted up, and in fine weather the delights of the sail from Vancouver northward through the inside passage have to be experienced to be realized. The great many waterways intersecting the group afford access to a relatively large area, but once away from the coast line, traveling may be pursued only on foot, and often with no little difficulty, owing to the decayed vegetation covering the surface. Outfits and supplies for parties working in the interior are transported when waterways are not available, by packing on men's backs, which greatly increases the cost of exploration and prospecting, as well as adding to the difficulty of traveling.

HISTORY

Published authentic information about the Queen Charlotte Group is meagre, and is almost wholly contained in the reports of the Geological Survey of Canada. The best general account of the islands is that given by Dawson[2] who examined the group in 1878. Besides fully treating the geology, Dawson gives an outline of the history of the group, and an account of the natives, the Haida Indians.

Dixon, in 1787, named the group after his ship, the *Queen Charlotte*, and also named several of the islands and surrounding waters. Before this time, they had been visited by several Spanish expeditions, and it is possible that DeFonte, in 1639, sailed among the islands.

A short chronologic outline of the history of the group is given below.

The first well authenticated visit seems to have been that of Ensign Perez, who reached the islands on July 18, 1774. After Perez, several other Spaniards visited the group, and many of the place names of today bear witness to the fact. The fur trade was the main attraction for the early navigators, and on the decline of this industry (to quote Dawson), "attention was . . . . withdrawn from the islands until 1852, when the Hudson Bay Company dispatched a party of men . . . to discover the locality from which . . . gold had

[1] Published by permission of the Director of the Geological Survey of Canada.
[2] Dawson, G. M. Geological Survey Canada. Rept. of Progress 1878-79, pp. 1B-239B, 14 plates, and geological map of the group.

been brought by the Indians. This was found to be in Port Kuper, or Gold Harbor, on the west coast. The gold was found in a small irregular vein, which was soon proved to run out in every direction. . . . The enterprise was soon abandoned, but the discovery for a time created quite a *furore*—the first gold excitement of British Columbia. . . ."

Coal was discovered at Skidegate Inlet in 1859 by a Mr. Downie, and in 1872 Mr. James Richardson made a report on this coal for the Geological Survey,[1] in response to requests made by Victoria men interested in the proposition. Then followed the work of Dawson in 1878, and nothing more is heard of the Queen Charlottes till 1905, when R. W. Ells made a reconnaissance of Graham Island. In 1912, in response to requests from companies prospecting on Graham Island for geologic aid in interpreting their results, Dr. C. H. Clapp, M. I. T. '05, then of the Geological Survey of Canada, made a three weeks' reconnaissance on Graham Island. Dr. Clapp's work made evident the necessity for a more thorough knowledge of the geology of the coal basins, and the investigation by the writer and his party was undertaken with this end in view. During this investigation able and efficient assistance was given by Mr. S. E. Slipper of Port Arthur, Ontario, and Mr. C. E. Cairnes, of Vancouver, B. C.

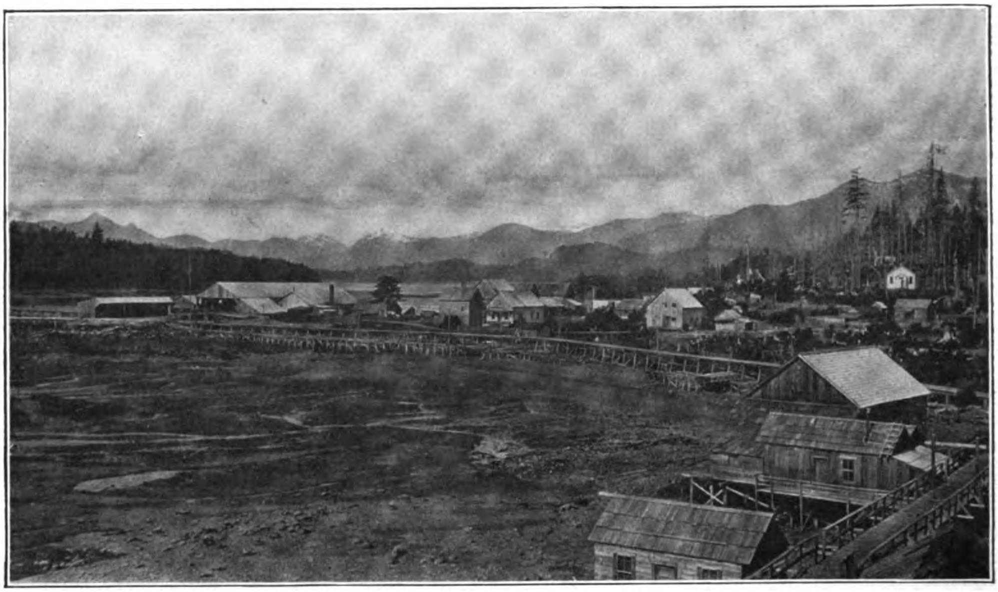
Packing

TOPOGRAPHY AND SCENERY

The principal islands of the group are, from north to south, Graham Island (the largest); Moresby Island, with Louise and Lyell Islands lying close to its east coast; and Kunghit, or Prevost Island, the southernmost. Besides these, there are numerous smaller islets ranging in size down to mere reefs, bare only at low tide, most of these being on the east side of the group.

The islands form part of one of the outer, largely submerged ranges of the northwestern Cordillera, and are generally considered to be the northwestern continuation of the submerged range forming Vancouver Island. Except for the northeastern part of Graham Island, which is low and flat, the group forms a rugged series of mountains, separated and indented by steep, intersecting fiords, the whole being called the Queen Charlotte Range. These mountains probably nowhere exceed 6,000 feet in altitude, if, indeed, they ever attain that elevation. Their rugged grandeur is accentuated by the fact that they nearly always start abruptly from sea level, rising in steep slopes and declivities, usually tree clad. The highest peaks are on Moresby Island, in the Sierra de San Christoval, and these, with others on this island, carry snow caps the year round. On northern slopes and in sheltered cirques and coulees snow

[1] Richardson, James. Geol. Survey Canada. Rept. of Progress, 1872–73, pp. 56–83.



Queen Charlotte City, eastern end

lasts over summer at levels down to 2,800 feet.

Characteristic of the Queen Charlottes are the inlets and fiords, two of which cut completely across the group, Skidegate Inlet and Channel, between Graham and Moresby, and Houston Stewart Channel, between Moresby and Kunghit Islands. Especially south of Skidegate Inlet numerous other straight or curved, steep walled, oftentimes gloomy fiords render access to the larger part of the group comparatively easy.

The scenery is always diversified and interesting, and often very beautiful. Along the coasts the combination of rugged mountain, steep, wooded slope, and blue, islet-dotted water, so characteristic of the Pacific Coast of Canada, lacks nothing of its usual charm. Evidences of human habitation are rare. Skidegate Inlet is particularly charming, and the views shown do it scant justice. The western expansion of this waterway, Waterfowl Bay, surrounded by high hills and studded with many little islands as it is, makes a never-to-be-forgotten scene. The abundance of wild life in this bay is noticeable, and from this fact arises the name. Sea-gulls, several varieties of ducks, eagles, and other birds are seen on every hand, while the glossy black head of the contemplative seal, or the curving back of the playful porpoise is a frequent sight for the traveler. In the interior the scenery is of another variety, and its charm (or lack of charm) depends largely on the weight of the pack and the condition of the trail. The dense forest prevents distant views from being seen, even from the hilltops, and, except occasionally, one has to be content with vistas near at hand. The forest, almost wholly conifers, is the dominating feature of interior travel. The open spaces in it, the muskegs (later described), but serve to accentuate its hold on the land. Burned areas are almost unknown, owing to the moist climate, and because lumbering as yet has not made inroads on the trees, and everywhere the untouched growth of centuries meets one's gaze. If there is a "forest primeval" in Canada, the Queen Charlottes may lay claim to it.

The view from Mount Etheline, southeast of Yakoun Lake, in the south central part of Graham Island, is impressive in the tremendous expanse of forest-clad

mountain, valley and plain that it discloses. From this high point, at an elevation of 2,590 feet, nearly the whole of northern and eastern Graham Island may be seen, as well as Hecate Straits and the coast ranges of the mainland of British Columbia and Alaska. From the summit of Mt. Kahgan, a sharp peak which overlooks Skidegate Inlet, and with

Eagle totem pole, east end Maude Island

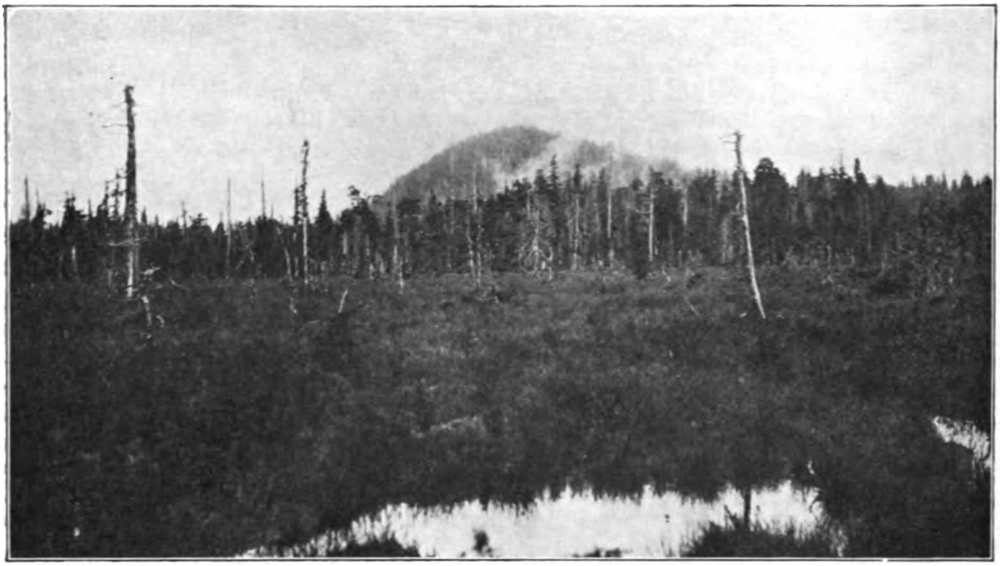
an elevation of 3,280 feet is the highest point in south central Graham Island, a wonderful outlook is obtained. Skidegate Inlet is spread out below like a map, and the islands and headlands appear as if etched against the background of the sea. Westward the extremely wild and rugged Queen Charlotte Range crosses from Moresby to Graham Island, and hurries northward, in steep serrate peaks, to die out in the northern part of the island.

Any account of the group would be incomplete without mention of the magnificent hard-packed sea beach on the northern coast of Graham Island, extending southwestward from Rose Spit. This is, doubtless, the finest beach in Canada.

CLIMATE, FLORA AND FAUNA

It is almost a characteristic of the northern Pacific Coast that the combination of high mountain ramparts, and the prevailing moisture-laden winds from the Pacific cause considerable local variations in climate. This is well illustrated in the Puget Sound region, and also in the Queen Charlotte Islands. The west coast is markedly wetter, and has more gloomy days than the east coast, and in the wider northern islands their western and central portion gets more rain than the northeastern lowland. The climate of the whole group, though thus locally varying, may be described as mild, extremes of heat and cold being seldom experienced in the lower levels. The summers are cool, with considerable dark weather and rain, but also with abundant sunshine. The autumn is very wet, but the winter is said to be mild, with considerable fine weather and less snowfall than Vancouver. Residents of Queen Charlotte City state that overcoats are seldom worn.

Vegetation is abundant. The principal forest tree is hemlock, usually not attaining great size, as trees go on the coast, perhaps averaging less than three feet in diameter. Besides hemlock, cedar, both red and yellow, and spruce are other commonly occurring forest trees while alder, yew, jack pine and mountain hemlock are also found. Most of the spruces are magnificent trees, some of them being eight feet in diameter at five feet above the ground, and towering to 300 feet in the air, carrying their size well up the stem. The yellow cedar is a wood worth special mention. It is light lemon yellow or cream color, extremely close grained, though not very hard, and works beautifully with edged tools, and takes also an



Muskeg on Wilson Trail

excellent polish. For interior finishing or furniture, this wood is very well adapted, and the best lumber comes from the Queen Charlottes. It does not occur in large stands (the same may be said of the spruce), and at present is not logged to any extent.

Undergrowth, except in the valley bottoms and on coastal lowlands, is not excessively abundant. Over the uplands, the principal shrub is a scraggly huckleberry, that delays, but does not seriously impede progress, and even this is sometimes lacking. In the low areas, various shrubs grow very thickly, including huckleberries, salmonberries, devil's club, etc., and traveling here is often slow and arduous. Extracting the insinuating thorns of the devil's club from the hands and other parts of the person is one of the constant diversions of the sojourner in the forests of the group.

The surface of the ground, encumbered as it is by layers of dead trees and moss, is usually very rough, and a secure footing is not always obtainable. The trees often raise themselves on buttressed roots above the lower soil level, causing hollows to form around and under the roots, which occasionally trap the unwary. It is curious, also, to see a prostrate tree trunk the site of a whole row of younger trees, these parasitic hedges often attaining considerable size. As some one remarked, "On the Queen Charlottes the woods are three tiers deep." Rank growths of fireweed, bracken, and such weedy annuals are common in the more sunny places, and this sort of vegetation grows very rapidly, forming in some cases thickets very difficult and disagreeable to penetrate.

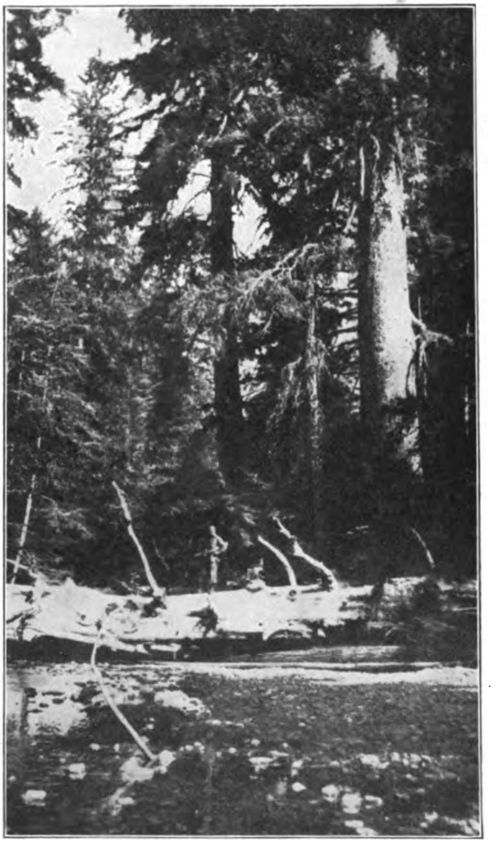
The features termed muskegs merit a word of description. They are of frequent occurrence and of widely varying size. They form wherever there is a break in the slope of the land, causing a bench and impeding drainage, and very large ones form on the flat topped elevations in the interior. It is not necessary that the bench or flattened area be level, for the surfaces of these muskegs at times slope as much as 15° from the horizontal. The muskegs are open spaces, frequently dotted with trees, either isolated or in straggly patches. The surface of the muskeg is a tough, matted peaty mass of decayed grasses, moss, and stems, interlaced with the roots of the plants growing on the top. These plants are various

grasses, with broad leaved plants, mosses, Labrador tea, low-bush blueberries, squawberries, etc. A low, bushy pine, mountain hemlock, and stunted jack pine are the usual trees on the muskegs. Scattered irregularly over the surface are stagnant pools of water, filled usually to within about a foot of the general level, and containing immediately below the water surface a flocculent mass of brown decayed vegetable matter, thickening with depth. The depth of these pools is considerable, and it is easy to thrust a pole down ten feet or more in many of them. It is common to find the water in pools not five feet apart remaining apparently constant at levels varying by as much as a foot, due to the verv slow seepage through the peaty material below the surface.

These muskegs, constantly wet as they are, do not allow of rapid walking, but are preferable as routes for trails to the unbroken forest, as the surface is smooth, and the impedimenta of roots and underbrush are lacking. The muskegs are, doubtless, caused by the moist, equable climate, permitting a very rapid growth of vegetation. Some of these open spaces are almost half a mile in diameter, and their wind swept appearance on a stormy day is desolate and forbidding. In fine weather, however, they form a welcome interlude to the monotony of the forest.

The water life of the coast has been mentioned. Halibut and salmon abound in the surrounding seas, and are sought after for canning purposes. In the forests, wild life is not abundant. Black bear are common, but they are the only species of frequent occurrence, and although their signs are continually met with, the animal himself has a remarkable ability for effacing himself from the landscape, and when surprised usually disappears with ludicrous but effective despatch. Marten and probably otter are found, but elk and deer are not at present indigenous to the group, though a few of the latter have been introduced by the provincial government. Their absence is the more remarkable because on the islands fringing the mainland, deer are found in abundance. Wild cattle were formerly abundant on Graham Island, but now are very scarce, though a few were killed last summer near Rose Spit.

Song birds are rarely met with, although a note like that of a song sparrow is heard once in a while. Hummingbirds, those startling iridescent bits of animation, are frequently found, and one never seems to get accustomed to the abrupt whirring announcement of their presence.



Spruce trees on Hidden Creek

SETTLEMENTS AND AGRICULTURE

Queen Charlotte City, on the south end of Graham Island, with a population not exceeding 150, is the largest settlement on the islands. At Skidegate Village, about three miles east of Charlotte, there are a few houses, and oil

Skidegate Indian Village

works of the B. C. Fisheries Company. Alliford Bay, on the southern side of the inlet, is a small hamlet owing its existence to the canneries of the same company. Skidegate Indian Village, near the entrance to the inlet of that name, is populated almost wholly by Indians. Masset, and Naden Harbor, on the north coast, and Queenstown on Masset Inlet are some of the other villages on Graham Island, while Pacofi, Lockeport, Ikeda and Jedway are settlements on Moresby Island.

Ranching is confined to the northeastern lowland of Graham Island, though a few small ranches are worked on some of the islands in Skidegate Inlet. Graham Island, in common with some other western communities, has suffered at the hands of unscrupulous real estate boomers, and various misrepresentations, both favorable and unfavorable have been given publicity. If local conditions in regard to agriculture are intelligently studied, men with ability and some capital to start operations should make a success of farming. Several ranchers are attaining considerable success with various crops in the northeastern lowland, and at least one man has proved stock farming to be profitable here. Vegetables of excellent size and flavor are grown on Graham Island, the potatoes being especially fine.

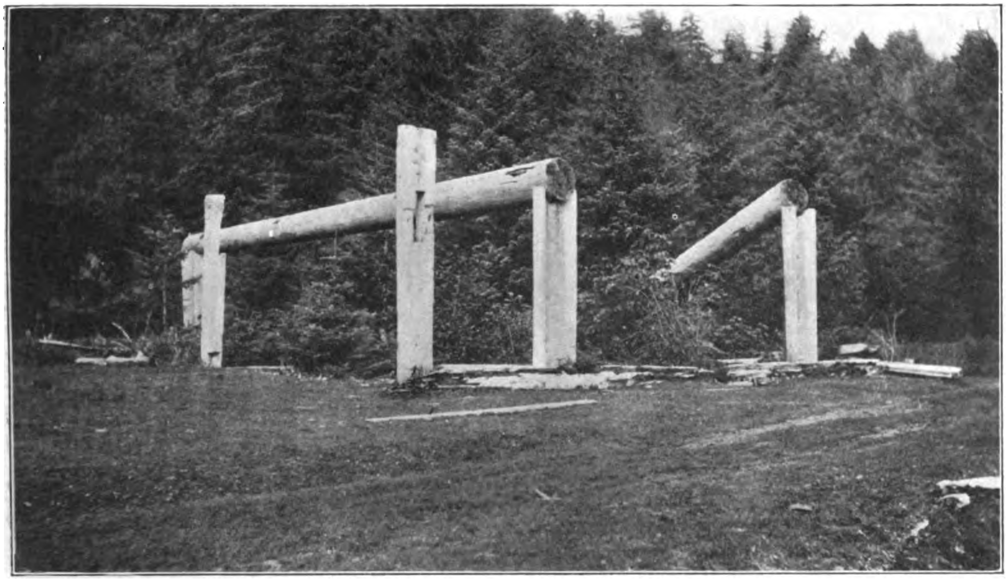
NATIVES

The natives of the Queen Charlotte Islands, the Haida[1] Indians, have been fully described by Dawson in an interesting appendix[2] to his report on the group, and the following account in part abstracted from that memoir.

The Haida nation appears to be one of the best defined groups of tribes of the northwest coast, and their original territory, as far as tradition carries us back, is the Queen Charlotte Group.

The Haidas are markedly fairer skinned than most of the coast tribes, and possess somewhat finer features. This characteristic is at present even more marked than when Dawson noted it, owing to admixture of white blood since that time, and it is startling to see blue-eyed children with yellow hair, playing on the beach in front of the villages. The most striking

[1] Pronounced hy'-dah.
[2] Dawson, G. M. Geol. Survey Canada. Rept. of Progress, 1878–79, pp. 103B–189B.



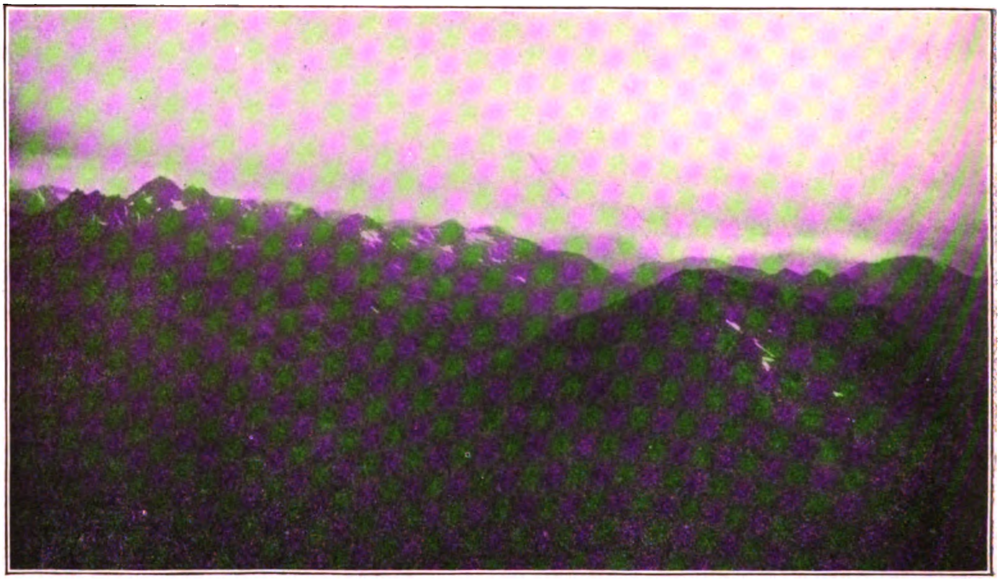
Framework of old Indian house

departures from European ideas of symmetry are found in the large mouth, width and prominence of the cheek-bones, and the disproportionately large head. The body is not infrequently large and long as compared with the legs, perhaps brought about by the constant occupation of these people in canoes, and their infrequent land excursions.

The native houses are strongly built of large timbers carefully fitted together, although but few of these houses are now to be found, and these more or less ruined. The carved posts, commonly termed totem poles, are especially well developed among the Haidas, and often elaborate and curious, indeed, is their ornamentation.

The permanent villages, very few of which are still inhabited, were generally situated with regard to easy access to the fishing grounds. For this reason they were often in exposed places, but a shelving beach on which canoes could be easily landed was always a necessity. The houses were arranged side by side, and a space remained between the fronts of the houses and the edge of the bank, serving for a street, as well as for the erection of the carved posts. These carved posts are broadly divided into two classes, one variety formerly being found before every house, the other sort having been erected in memory of the dead. The first kind are the more highly ornamental, and are from 30 to 50 feet high, three feet or more wide at the base, and tapering slightly upward. These posts are generally covered with grotesque, somewhat conventional figures, closely grouped together, from base to summit. Models of these posts, carved from a hard, black carbonaceous shale found in the Slate Chuck Valley, are made by the Haidas even to the present time, though they become scarcer every year, as the younger Indians do not take up the arts of their fathers.

The monumental posts have a greater diversity of design. A common form consists of a stout, plain, upright post, round in section, and tapering slightly downwards, one side of the top flattened. To this is affixed a sign-board-like oblong of hewn cedar planks, which may be painted or decorated. Another form consists of a round, upright post with a carved eagle or other figure at the summit. The carving of some of these birds is strikingly realistic. Still other poles are



Looking west over Queen Charlotte Range from Mt. Kahgan

carved only at the base, and run upwards into a long round post with incised rings about four feet apart. The simplest form of post is merely a round straight tree, with the branches and bark trimmed off, and resembling a flag pole.

Many other curious and interesting facts are given in Dawson's account.

While inquiring the names of localities about Skidegate Inlet from one of the older natives, the present writer was interested to learn that the Haida name for Alliford Bay—Ghatz-rrunday, as near as it may be set down—signifies in the language of my informant "sometime, all this place shake (shaking his hands) all same ghatz-rrunday." It seems quite possible that some of the earthquakes, so prevalent farther north in Alaska, may have effected this region not so long ago.

GEOLOGY

The Queen Charlotte Islands have had an eventful geologic career, the story of which may be deciphered from rocks which date back to early Mesozoic times. The oldest rocks exposed belong to the Vancouver Group, largely volcanic in its nature, composed of consolidated ash rocks and lavas but containing also metamorphosed mud rocks and limestone members. This formation was in large part accumulated under water. The Vancouver Group is widespread in the Pacific Coast region of Canada, and is an important geologic formation. After its accumulation it was folded by mountain building forces and later was intruded, and in large volumes replaced by the deep-seated granular igneous rocks of the great Coast Range batholith. These plutonic rocks are generally supposed to be Upper Jurassic in date. On the Queen Charlotte Islands they are exposed in rather small, separate areas at the surface.

After the folding and batholithic intrusion, the mountains formed by the uplift were partly worn away by processes of denudation, and once more, in Cretaceous time, the area was the scene of extensive marine sedimentation. The surface on which the basal rocks of the Cretaceous series were laid down was a very uneven one, probably resembling to some extent the topographic conditions found in Skidegate Inlet today. The Cretaceous sandstones, shales and conglomerates accumulated to a thickness of the order

of 10,000 feet, and many zones are highly fossiliferous. In the lower part of the rocks coal occurs, at a single rather extensive horizon.

After, and to some extent during the building up of this great series of sediments they were invaded by igneous rocks in the shape of sills and dikes, and a second elevation of the group then took place, again causing great denudation, and from much of the surface the Cretaceous rocks were removed. On this surface were poured out great floods of lava in Tertiary times, and volcanic action may have continued throughout most of the Tertiary period. These lavas are associated with marine sediments, so the land then stood somewhat lower than at present. A third great erosion period, continuing to the present time has shaped the topography as now seen, and a relatively recent slight uplift has taken place. Cretaceous and Tertiary rocks are now virtually confined to Graham Island, the islands south of Skidegate Inlet being formed of pre-Cretaceous rocks, mostly belonging to the Vancouver Group.

Coal, the investigation of which was our particular object, has been found at several localities on Graham Island, and around Skidegate Inlet. The most important localities are on Graham Island, at Cowgitz and in the Slate Chuck Valley, near Skidegate Inlet; and at Camps Anthracite, Trilby, Robertson and Wilson in the interior. At all of these localities the coal is of lower Cretaceous age, and occurs at a single horizon, repeated by folding. It is possible that the coal at Camp Wilson occurs at a lower horizon than that in the other basins. The coal at Cowgitz, Slate Chuck and Camp Trilby, near Yakoun Lake, has been altered by some sort of volcanic action to an anthracitic variety. At Camps Robertson and Wilson, the most promising prospects, the coal is bituminous, rather high in ash. The structure of the coal basins is synclinal, and large faults have not been located; they are rare or absent.

Lignite of Tertiary age occurs at Skonun Point on the north coast of Graham Island, and at other localities also. This lignite is a future resource of value.

Deposits of metallic minerals are almost wholly confined to the islands south of Skidegate Inlet, and, with the exception of the Southeaster and Beaconsfield claims, on Graham Island, none of these were visited by the writer this year. The occurrence of gold at Gold Harbor has already been noted; here the gold is said to occur in a quartz vein in volcanic breccias. In Cumshewa Inlet, several men are actively prospecting a gold-silver-lead deposit, which is reported to be of considerable value. At Copper Bay, between Skidegate and Cumshewa Inlets, is a very old shaft sunk on a copper-bearing vein, and copper is also found at Lockeport, Ikeda, Jedway and Tasoo Harbor.

Prospecting for oil by means of drilling is being carried out at Otard Bay, on the northwest coast of Graham Island. The clay deposits of northern Graham Island are of value, though as yet no high-grade clays have been found.

The writer is indebted to Dr. F. H. Lahee for criticism and advice in the preparation of this article.

THE STRENGTH OF ANTS

An ant can carry a grain of corn ten times the weight of its body; while a man or horse can carry loads only about equal to its bodily weight.

It is not a fact, however, that the ant is greatly superior in strength. If an ant should grow to twice its original size, still retaining its geometrical and histological structure, its volume and accordingly the weight of its body would increase eightfold. Although the muscles grow to twice their original dimensions, the increase in length does not increase the strength, which is proportional to their cross-section, and the ant would only be four times as strong as before. As it now carries but five times its weight, however, it is relatively only half as strong.

It is calculated that the same ant developed to the size of a man would only be able to carry 1-100 of its own weight, instead of ten times its own weight.

EYE DEFECTS OF BACKWARD CHILDREN

AN OVERLOOKED OBSTACLE TO THE MENTAL DEVELOPMENT OF THE CHILD THAT IS RESPONSIBLE FOR MUCH SUFFERING AND LOSS OF MENTAL POWER

BY MORTIMER FRANK

THE increased demands of school life and the rapid advances in educational methods have made the physical well-being of the child a more and more important factor in education. Educational institutions of today protect and develop the physical condition of the child, side by side with the mind, but the dull and backward pupil who is mentally deficient because of improper functioning of the eyes is more or less neglected. There is no physical defect that interferes with or even prevents the progress of a child in school so much as defective vision and there is no defect so easily and cheaply remedied. Children with defective eyes must be divided into two classes: first, those who are really mentally deficient, and whose defective eyes simply make their condition more pronounced, and, second, those whose minds are normal, but who are dull and backward because of their inability to overcome their eye defects without a great or often impossible expenditure of nerve force. It is for the pupil of this latter class that the greatest efforts on our part should be exerted. They are the children for whom and upon whom especial thought should be bestowed. Within a few years reading was taught by a slow and cumbersome method. Few children enjoyed the reading of a book until the third school year, but today this is all changed. By the present methods of teaching reading the child reads simple books at home for his own pleasure before the first year is ended. The loss of nervous energy necessitated by reading and writing at the ages of from 5 to 8 years is an unwarranted drain upon the health of the child. Instead of giving the child the free and vigorous movements of the larger muscles at this age, the use of the smaller ones with their finer adjustments for reading and writing are brought into play.

The sacrifices caused by this premature strain in this age of rush and the influence upon the one organ—the eye—which is abused more than any other, can not be over-estimated. Few realize how enormously complicated is the act of reading and how many difficulties must be conquered before the printed word becomes the spoken word, never stopping to consider that all this mysterious and difficult adjustment must be made in early childhood. Imagine for a moment the immense difficulty the young child must experience in learning to direct and control the necessary movements of the eyes in the act of reading. The effort made to follow the printed line from side to side, to fixate particular sentences, words or letters hampered by the inherent physiologic incompleteness of childhood. From observation and examination of a very large number of foreign-born children who frequent the eye department of the West Side Hebrew Dispensary, I am convinced that not only are defective eyes very common, but, owing to neglect, lack of proper food, air, care and hygiene, these defects are much more serious on the average than among native-born. Examine these eyes and you will perhaps find corneal opacities or a congenital cataract or, what interests us particularly, some remediable error of refraction. Place this child in a school where his defects are overlooked and what results? An immense amount of physical suffering, expressed or endured without complaint. In childhood and early adolescence, the plastic period of growth, the eye ball is soft and yielding, and the strain

of the ciliary muscle and those of the globe are productive of changes in its shape. The hyperopic eye is the most frequently observed in these cases and the one entirely misunderstood by parents and teachers. Unless the hyperopia is of high degree the child can often read the 6/6 or 6/5 line at 6 meters as readily as the child with normal eyes, and for a time can often read the finest type at 12 inches. This eye, when at rest, has its distance image formed back of the retina, and to see clearly must use its power of accommodation oftentimes much in excess of the amount necessary for the normal eye to accommodate at the ordinary reading distance. When the eye is used for close work there is the usual accommodative effort for the near point, added to the amount already in use for distance. This combined effort is much too great. The ciliary muscle can not keep it up and so the accommodation soon relaxes, the type becomes blurred and the book is dropped. A child with such eyes finds it impossible to keep the print clear, no matter how large, and will finally cease to make any effort, with the result that he fails to keep pace with his fellow-pupils. If such a child is naturally dull, the inability to study makes the dulness very much more marked.

The high degrees of hyperopia are easily detected, as such eyes can not accommodate sufficiently to get clear distant vision, and, in order to get as large a retinal image as possible, holds the school book within a few inches of the eye. These cases are often wrongly diagnosed as myopia and sent to the ophthalmologist as such. Pass from this type to another where the hyperopia is of low grade and the least easily detected. This is the child who has excellent vision, learns readily and is interested in things about him, but neglects his studies, and his failure to do well at school is attributed to deliberate neglect on the part of his overworked teacher. He begins the day at school well enough, is bright, but has a reputation of being lazy, idle and mischievous. He tires soon of his work and is constantly reprimanded. The difficulty with him is that, while his eyes are keen enough for transient distant vision, his eyes tire after a short application for close work and begin to wander. He can not keep up on account of his inability to overcome his eye defect without a great or often impossible expenditure of nerve force. If he is closely watched each afternoon he has headache, pain or more or less general discomfort in the eyes. Such a child can not possibly have the pleasure in learning a normal child should have.

If we consider eyes normal because a child can see the blackboard from the back seat and read the normal line of the test-type, we are overlooking a large number of children whose eyes are causing them great suffering, for the child with a moderate amount of astigmatism may also by an effort of accommodation, or by partly closing the eyelids, be able to pass the school test, as does a child with normal distant and near vision. In astigmatism the curvature of the cornea is not uniform, being greater in one meridian than in another. Eventually the great effort to maintain this vision soon produces general discomfort, he falls behind in his class, there is a disinclination to study, he hates school and becomes a truant. The backward child with myopia demands the greatest care. Doomed often from childhood in failing to have his childish imagination stimulated by the beautiful things in Nature, his work is bounded by a few inches beyond his nose. He can not see to play the games of his schoolmates, and, though put in a seat close to the blackboard, derives slight benefit from it, and what is seen is obtained only with a strain. Later on, when information can be derived from books, there is an added danger from his myopia becoming progressive. He sees to read by holding the print close to his eyes, but loses tremendously by reason of his defect. The eyes are more or less diseased and consequently become more and more myopic until vision is greatly reduced, and the earlier we can correct the refractive anomalies by the aid of proper glasses the more we shall help their eyes and brain.

Even worse off is the child whose sight

is impaired by opacities resulting from disease or neglect. With his distant vision as poor as the myope he has added the spotting and distortion of near objects by the constant shadow of his opacity. He earns a reputation for stupidity, idleness and inattention and is the butt of his better-equipped mates. Less common than refractive errors, but often dependent upon them, is a lack of perfect balance of the extraocular muscles which make possible the movements of the eyes. Activity on the part of these muscles is excessively fatiguing and any cause which would affect their nerve centers would, in turn, affect the eye movements by which reading is made possible. The backward child with whom nerve exhaustion is the usual condition finds it a task beyond his strength to follow with accuracy and speed the mysteries of the printed page and is constantly losing his place and slipping off the line. Every child struggling with one of the foregoing conditions is working at a disadvantage. The demands of school life are so great that even a normal eye fails, and refractive errors develop, and it is no wonder, then, that the imperfect eye must suffer. I personally have seen many apparently dull and backward children transformed into bright, energetic pupils by the benefits derived from improved eye conditions. The number of dull or backward children with imperfect vision is entirely too great to be accounted for on the ground of mere coincidence.

In view of the fact that investigation showed that 60 per cent. of children examined in the Philadelphia schools had eyestrain or defective vision, the city in 1907 established an ophthalmologic division of the bureau of health. The city council appropriated $300 for glasses for children unable to pay for them, and with this money 354 children were fitted with glasses. These children without glasses could not read from the blackboard and could not see the print in their books; in many instances they were thought backward and often mentally deficient. The correction of these defects by the fitting of proper glasses was followed by remarkable improvement in the work and conduct of the pupils. Children in special schools were enabled to return to the regular schools. Dr. Joseph L. Neff, director of the Department of Public Health and Charities, considers that the report of the first three months' work has demonstrated that many so-called mental defectives and incorrigibles do not really belong in that category. The report emphasizes the fact that the expense incurred is more than counterbalanced by the increased worth of an educated citizen over an illiterate one who may become a public charge, or whose earning capacity is so curtailed that he can contribute but a small amount to the support of the state. Dr. Neff believes that in many cases such children would have joined the criminal classes or in some way have become a burden on the community.

From a study of the subject and my personal experience I would offer the following conclusions:

1. That refractive errors are unusually frequent among backward children.
2. That the correction of these defects by the fitting of proper glasses is followed by remarkable improvement of the mental power and allows the apparently backward child to keep up with his mates.
3. That it would be decidedly good policy to have the eyes of all children with real or apparent mental deficiency thoroughly examined as a matter of routine.

A RAILWAY IN ICELAND

Plans are now complete for the first railway in Iceland. It is to be run from the capital, Reykjavik, over the Thingvalla plain to the Olfusa bridge, a distance of about fifty-eight miles, and will cost about $1,000,000. The railroad will be continued ultimately to Thorsjaa, and from there one branch will lead to the geysers and the other to Oerbak.

The present methods of traveling are extremely primitive, the roads being few and poorly maintained, and with few bridges over rivers. In general island journeys are made on horseback, over bridle-paths or trails, and the streams have to be forded.

THE MYSTERIOUS EEL

ITS LIFE HISTORY HAS BEEN A PUZZLE TO NATURALISTS FOR CENTURIES AND THERE IS A GREAT DEAL YET TO BE LEARNED ABOUT IT

A DEEP mystery surrounds the lives and habits of many familiar fishes, and the deepest of all, with few exceptions, enveloped the life history of the eel for thousands of years. Theories, rank and fantastic, curious and impossible, environed the snakelike fish, and some are still believed, and much of the mystery has not to this day been entirely cleared away by scientific men.

Mr. W. E. Meehan, commissioner of fisheries of Pennsylvania who writes interestingly about them in the New York *Sun*, says that Aristotle, who for centuries was venerated as the greatest of scientific men, declared that eels were sexless and were produced spontaneously from "the entrails of the sea." Pliny agreed that the fish was without sex, but advanced a different theory of generation. He declared that a mature eel rubbed its body against a submerged rock, and the slime which was detached separated into small particles and became imbued with life.

Nowadays with a sense of superior knowledge people smile over the fantastic theories of Aristotle, Pliny and many other scholars of later date, but what they proclaimed was scarcely more grotesque or absurd than a belief widely current today, that eels are developed from hairs of horses.

Some 1,200 years after the death of Pliny scientific men began to assert that eels do possess sex, but they held that the young were born alive from the female. A careful search for verification followed which lasted for nearly a century before the sex theory was demonstrated. It was just a year after the Declaration of Independence that Mondini, a distinguished Italian naturalist, discovered a female eel, and demonstrated clearly that the eggs were deposited and the young hatched in the same way as those of other fishes.

The male eel was not identified until 1873. Before that time and after Mondini's discovery the lamprey, which, by the way, is not a true fish, was generally believed to be the male of the eel, and even at the present time there are many intelligent persons who still maintain this idea.

There remains much to be learned of the life history of the eel, but what is known is of deep interest. Some of the facts are almost as astonishing as the theories held by our forebears.

The common eel is a fresh water fish which for some undiscovered reason requires salt water in which to spawn. In this particular it is the reverse of the shad, for that delicious food fish belongs in salt water but must when spawning time comes make its way into fresh water. It is because of this spawning requirement that eels are rarely found in the Allegheny River. The headwaters of that stream are too far from the Gulf of Mexico for the fish to make a trip down and up within twelve months.

The great journey to the sea begins about the middle of August. From every pond and mountain lake, from every stream, brook or waterway, eels swarm into the principal rivers and make their sinuous way southward by millions, all with one common purpose, to reach the mud banks in the shallows of the bay, there to spawn.

Some of the vast aggregation do not go and the question may well be asked, Why? The answer is apparently simple. The stay at homes are believed to be barren, or have not reached the spawning age and therefore are without the instinct and impulse to turn seaward. While this

theory has not been definitely proved, it is plausible.

Only capture or death can prevent the eel, having once started seaward, from continuing its journey and fulfilling its mission. Nothing could more forcibly illustrate the truth of the great doctrine enunciated by the late Thomas Meehan before the American Association for the Advancement of Science, that "self-sacrifice plays as great and important a part in nature as the 'struggle for existence,' " for at the end of the journey death awaits the majority.

The eggs of the eel, which are very minute, do not develop until brackish water is reached; then ripening begins, and it is completed within a few weeks. It is because the ova are immature and also very minute while the fish are in fresh water that the secret of sex was so long concealed from scientific men as well as laymen. Not even the enormous number of eggs which every female possesses, and it runs into the millions, gave assistance to their detection.

Often fishermen are aware of habits unsuspected by scientific men who make a study of ichthyology, and one phase of eel life affords a good example of this. The general impression among scientific men is that all eels die after spawning. This statement was made before an association of the most eminent fish culturists and ichthyologists in the country only three years ago by a man who had made a special study of the eel, and who was amazed when his statement was controverted by a fish culturist from Pennsylvania.

While many river fishermen know nothing of the spawning habits of the eel and numbers of them believe absurd stories concerning it, all know from actual experience that every spring there is a run of mature eels up stream, a run of huge dimensions, and they catch them by setting their nets down instead of up stream. Thus while a large proportion of eels may and doubtless do die, a goodly number survive.

The progress of the fish from the sea to the haunts they left the summer before is as persistent as that on their way to salt water. If they come to a dam, a waterfall or anything in a river or stream which they cannot surmount they do not hesitate to leave the water on a dark rainy night and take to land, wriggle around the obstruction and continue their journey up stream.

It is declared that if when on land they meet with food they will seize and eat it. One careful investigator says that he has seen eels crawling across a plot of short wet grass. stop, seize and swallow earthworms.

The eel is a carnivorous fish and to some extent a scavenger, and while classed among the slower moving fishes it has acquired much skill and exercises great ingenuity in pursuing and capturing its prey. Not even the lightning-like moving trout and pickerel can always be sure of escape.

The eel also shares with most other fishes a great fondness for fish spawn. Heartbreaking tales are related by men who want destructive devices permitted, of the destruction eels wreak in this particular, and they invariably conclude by arguing that although the baskets and outlines and sundry other forbidden fishing devices may catch other fish also they should be permitted so as to exterminate the eel. But the eel, like other creatures that have a bad name, is less black than it is painted.

Two other characteristics of the eel are not generally known, and they are very interesting. One is that it, in common with other fishes, has scales. This statement is likely to be received with incredulity by the vast majority of those familiar with the slimy, serpentlike fish who have had frequent and abundant evidence of its superlative knowledge of intricate knot tying in fishing lines; but it is nevertheless a short statement of a scientific fact. The scales are microscopic and imbedded in a thick, mucous skin and invisible to the naked eye.

A second characteristic not universally known is the presence of an active poison in the blood of the eel, a poison sufficiently virulent, it is said, to prove mortal to a human being inoculated with it. Fortunately the poison is not seriously harm-

ful if taken into the stomach and it entirely disappears when subjected to heat; consequently the publication of this peculiar feature of an eel's makeup need not lead a person who enjoys its flesh to deny himself his favorite dish.

As a concluding note it might be stated of this fish, which has given so much trouble to scientific men, and also to unscientific men and boys who have had their lines helplessly tangled while fishing, that the stay-at-home eels do not disport themselves in the water throughout the winter, but with the coming of cold weather bury themselves in the mud, where they sleep comfortably until spring.

LIFE FROM LIFELESS MATERIAL

In an address delivered before the British Association, President E. A. Schäfer said:—

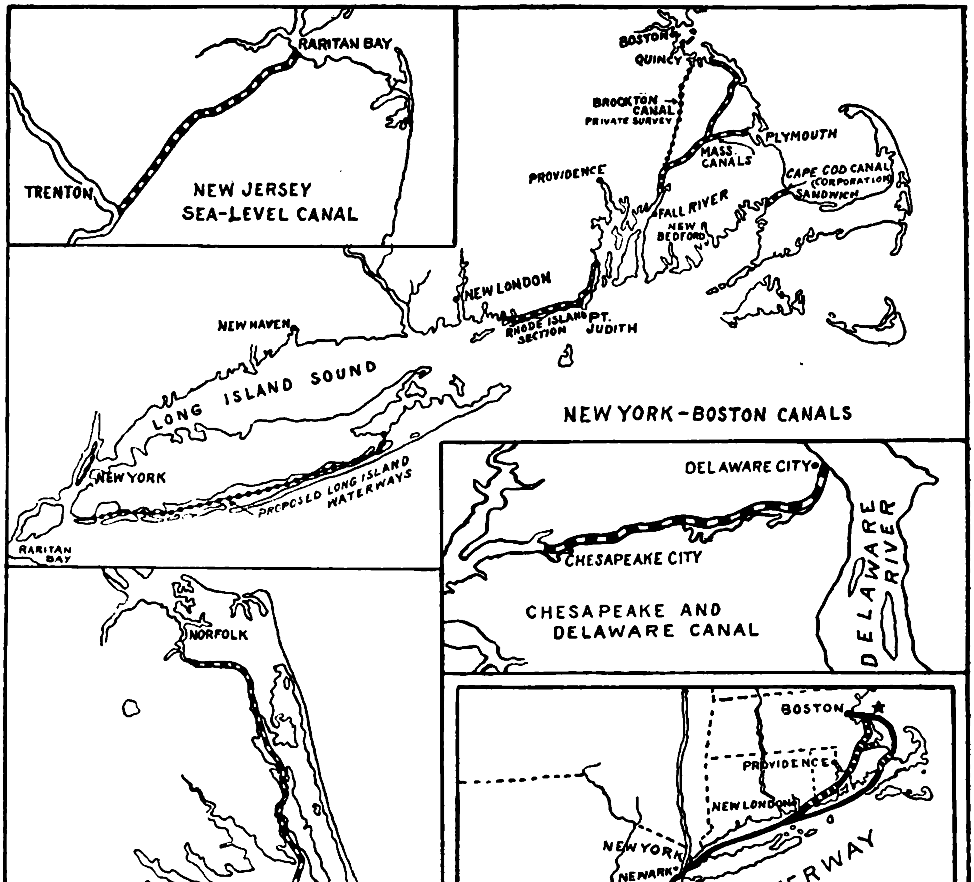
There is, it must be admitted, nothing new in the idea that living matter must at some time or another have been formed from lifeless material, for in spite of the dictum *omne vivum e vivo*, there was certainly a period in the history of the earth when our planet could have supported no kind of life, as we understand the word; there can, therefore, exist no difference of opinion upon this point among scientific thinkers. Nor is it the first time that the possibility of the synthetic production of living substance in the laboratory has been suggested. But only those who are ignorant of the progress which biochemistry has made in recent years would be bold enough to affirm that the subject is not more advanced than in the days of Tyndall and of Huxley, who showed the true scientific instinct in affirming a belief in the original formation of life from lifeless material and in hinting at the possibility of its eventual synthesis, although there was then far less foundation upon which to base such an opinion than we of the present day possess. The investigations of Fischer, of Abderhalden, of Hopkins, and of others too numerous to mention, have thrown a flood of light upon the constitution of the materials of which living substance is composed; and, in particular, the epoch making researches of Kossel into the chemical composition of nuclear substance—which in certain forms may be regarded as the simplest type of living matter, while it is certainly the *fons et origo* of all active chemical processes within most cells—have shown how much less complex in chemical nature this substance may be than physiologists were a few years ago accustomed to regard it. On this and other grounds it has lately been independently suggested by Prof. Minchin that the first living material originally took the form, not of what is commonly termed protoplasm, but of nuclear matter or chromatin: a suggestion which seems by no means improbable.

WHAT IS SLEEP?

In an article on "Sleep" Dr. Boris Sidis says:

"Sleep is not a disease, not a pathological process due to the accumulation of toxic products in the brain or in the system generally. Sleep is not an abnormal condition, it is a normal state. Like the waking states, sleep states are part and parcel of the life-existence of the individual. Waking and sleeping are intimately related—they are two different manifestations of one and the same life-process —one is as normal and healthy as the other. One cannot help agreeing with Claperède's biological view that sleep is a positive function of the organism, that sleep belongs to the fundamental instincts. As Claperède forcibly puts it: 'Sleep is a protective function, an instinct having for end, in striking the animal with inertia, to prevent it from arriving at a condition of exhaustion. We sleep, not because we are poisoned or exhausted, but so that we shall be neither poisoned nor exhausted.' "

A California transmission company patrols its high-tension lines leading out of Oakland in an aeroplane. A lineman equipped with repair apparatus will ride with the aviator, and the pair will take trips twice a week. The headquarters of this novel inspection crew are to be established at Sacramento.



Courtesy of the *Scientific American*

The proposed system of intra-coastal canals, for which Congress is asked to make appropriations

A GREAT INLAND WATERWAY

Before retiring as chief of engineers of the army, Brigadier-General Bixby made a strong recommendation to Congress, advocating the construction of a system of intercoastal canals to form an inland waterway between Boston, Mass., and Beaufort, N. C.

Such a waterway would be of untold value to coastwise traffic as well as of great importance to the naval and military arms of the government; and the coastal conditions are all in favor of this project.

This enterprise has been advocated for many years by the Atlantic Deeper Waterways Association, through whose efforts the appropriation was made by Congress, which provided for a survey by army engineers to determine the feasibility of the scheme, and to estimate on the probable cost of construction. This commission was also to report as to whether the amount of traffic would warrant the construction of a complete system of intercoastal canals, and upon the naval and military advantages of this inland waterway in case of war. The other problem was the cost, size and type of canal to meet all conditions, present and future.

It is to be understood that this is intended to be the beginning of a greater scheme for building a line of canals from Boston entirely around the Atlantic and Gulf coasts to the Rio Grande.

The special board has been investigating this matter for a period of seven years and its conclusions, supplemented and amended by that of General Bixby, are as follows:

For the first section of the canal two alternatives were offered—the purchase of the privately owned Cape Cod canal or the building of a government-owned canal from Boston to Narragansett Bay, the cost of which would be about $10,000-000. The conclusion reached was that there is no immediate commercial necessity sufficient to justify the construction of a government-owned canal at the present time.

The second link is known as the Narragansett Bay-Long Island section. This route leaves Narragansett Bay at Bissel's Cove, following a series of tidal streams and lagoons to Long Island Sound, opposite Montauk Point, avoiding the dangers of navigation around Point Judith.

It was estimated that a canal 18 feet deep would cost about $12,000,000; while one 25 feet deep would cost twice as much.

The final conclusion reached was that such a canal would afford little saving of distance over the route via Long Island Sound, and that boats would probably prefer the latter except in stormy weather.

In cutting a canal from New York to the Delaware River, it was found inadvisable to purchase the existing Delaware and Raritan Canal, and a new sea-level canal was recommended, which would have a depth of 12 feet, sufficient for floating one and two-thousand-ton barges. The expense of this canal would be about $20,000,000, and it should be so built as to allow an economical enlargement to a depth of 25 feet, and so designed that it can be changed from a lock to a sea-level canal.

From the Delaware River to the Chesapeake Bay the route was surveyed along the line of the present Chesapeake and Delaware Canal. The building of a canal along this route would cost about $10,000-000, and the board recommended that the Chesapeake and Delaware Canal be acquired at a purchase price of $2,500,000. This canal is 10 feet deep and of the lock type. An appropriation of $8,000,000 was recommended to transform this canal into a sea-level with a depth of 12 feet throughout.

All practical routes from Norfolk to Beaufort were surveyed and the one selected was the route via the Albemarle and Chesapeake Canal, Currituck Sound, Alligator River, Rose Bay and Adams Creek. It was recommended that the

Albemarle and Chesapeake Canal be purchased for $500,000, $2,235,000 to be spent in improving it, and increasing its depth to 12 feet.

From Albemarle Sound to Beaufort inlet the estimated cost of construction is $2,600,000.

Congress has already made a start in the construction of this intercoastal canal by appropriating $800,000 for the Norfolk-Beaufort section, $500,000 of this amount to be spent for the purchase of the Albemarle and Chesapeake Canal.

In brief, the recommendation abandons for the present the section from Boston to New York, and recommends that Congress appropriate $30,000,000 for the construction of a 12-foot canal between New York and Norfolk, the canal from Norfolk to Beaufort having already been authorized.

FUTURE OF THE WIRELESS TELEPHONE

IN A recent address Professor Elihu Thomson said:—

"The practical success of the wireless telephone depends upon our ability to control the voice waves and to vary in accordance therewith the energy given out by the transmitting antennæ, and to do this with a fairly good output of energy. Much progress has been made in this department of wireless work, and such telephony between Europe and America may yet become practicable. Methods are being worked out whereby it may be possible to mould by microphone, outputs of many kilowatts of energy so as to have them vary with the voice waves, and when this is done, many problems, the solution of which now seems remote, may be solved and the results prove of great practical value to the world."

LARGEST MARINE DIESEL

THE recent arrival of the ship *Wotan* in New York Harbor, is of interest because the ship is propelled by a single-screw, six-cylinder, two thousand horse-power Carels-Diesel marine engine. Other motor ships that have come to this port, were driven by two engines of six or eight cylinders, whose gross capacity was about 2,000 h. p. and in each case they were supplied with injection air by additional engines. The motor of the *Wotan* is a six-cylinder engine with an injection air compressor on the engine. This is the largest marine Diesel engine in service, and the good record of the ship on her maiden voyage is another proof of the reliability of this type of drive.

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The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

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THE RADIUM SITUATION

THE NATURE OF RADIO-ACTIVE MATERIAL AND THE RADIUM RESOURCES OF THIS COUNTRY–STARTLING TESTIMONY AS TO ITS THERAPEUTIC IMPORTANCE

A LECTURE BY CHARLES L. PARSONS

IN ATTEMPTING to cover the radium situation as it exists today in the United States, a speaker cannot hope to more than skim the surface or give other than a general summary of the subject. In order that you may understand it clearly, I shall touch briefly not only on the physical and chemical properties of radio-active material, but shall also take up the economic side of the question, such as the occurrence of radium, the development of the ores in this country, and the value of radium in the treatment of disease.

By radio-active material is now generally meant that class of substances such as uranium, thorium, and their decomposition products, all of which possess the property of spontaneously emitting radiations and of giving off a continuous supply of energy without apparent stimulus or exhaustion.

The emission of energy by these substances cannot be retarded or accelerated; the energy comes from an unknown source; obeys unknown laws; and apparently comes out of nothing. Radium, for example, emits per unit mass more energy than any sun or star: if the sun were all radium it would give off heat and a light probably one million times greater than the present orb. This wonderful ebullition of energy by radio-active material has enabled chemists and physicists to discover elements that would otherwise have remained unknown, and to measure minute quantities of these elements with an accuracy far greater than the imagination can conceive.

When Henri Becquerel, in 1896, discovered, almost through accident, that uranium and its salts possessed the property of giving off rays that affected a photographic plate through material ordinarily opaque, no one could realize the effect the discovery was to have upon our conception of matter. Following Becquerel's announcement, there was much interest aroused in the scientific world as to the reason for these radiations. One theory proposed, among others, was that the ores of uranium contained a new substance with unusual properties. Professor and Madame Curie, working upon this supposition, analyzed with care the residues from pitchblende ore used in the extraction of uranium, as these residues had been

shown to be more radio-active than the ore itself. In the course of their work, they found that when the barium which the material contained was separated, it carried with it a large part of the radio-activity, and after many fractional crystallizations, by which this radio-activity was gradually increased, they were able to announce in 1898 the existence of a new element to which they gave the name "Radium."

Even preliminary notice of the properties of this element so startled the scientific world that it has not yet fully recovered its equanimity. Many scientific investigators have since studied radium, but the scarcity of the element has rendered progress slower than would otherwise have been the case. Among those who have developed our knowledge of the subject, Sir Ernest Rutherford, recently knighted for his discoveries, stands pre-eminent. His book on "Radio-active Substances and their Radiations" recently issued, will always remain a scientific classic.

In this connection it might be mentioned incidentally that, although radium was discovered in the eastern hemisphere, the western hemisphere should have the credit of developing a large portion of our present knowledge of the subject. This fact is not as widely realized as it should be. Rutherford and his distinguished co-worker, Soddy, both acquired their reputations at McGill University, Montreal, from which they later went to the University of Manchester and the University of Glasgow. Besides these, Boltwood of Yale, McCoy of Chicago, Schlundt of Missouri, Duane of Harvard, and Moore and Lind of the Bureau of Mines are thoroughly appreciated abroad for their contributions to the subject. Credit for many of the facts quoted in this paper should be given to the published works of these scientists.

It will be necessary to pass rapidly over some of the known facts. Uranium has been shown to be spontaneously decomposing, into definite products, the amounts, life periods, and radiations of which are shown in the following table:

TABLE I (Rutherford, page 468)

URANIUM SERIES

Uranium series	Atomic weight	Weight per kilogram of uranium	Half-value period	Rays	Range of α rays 15° C
Ur { Uranium 1	238	10^6 mg.	5×10^9 years.	α	2.5 cms.
↓ Uranium 2	234	196 " (?)	10^6 yrs. (?)	α	2.9 "
↘ Ur Y	230 (?)	8×10^{-7} mg.	1.5 days	β	—
↓ Uranium X	230	1.3×10^{-5} "	24.6 "	$\beta+\gamma$	—
↓ Ionium	230	39 mg (?)	2×10^5 yrs. (?)	α	3.00 "
↓ Radium	226	0.34 "	2000 yrs.	α	3.30 "

Radium, in its turn, continues to disintegrate into products, the quantities, life periods, and radiations of which are shown in Table II.

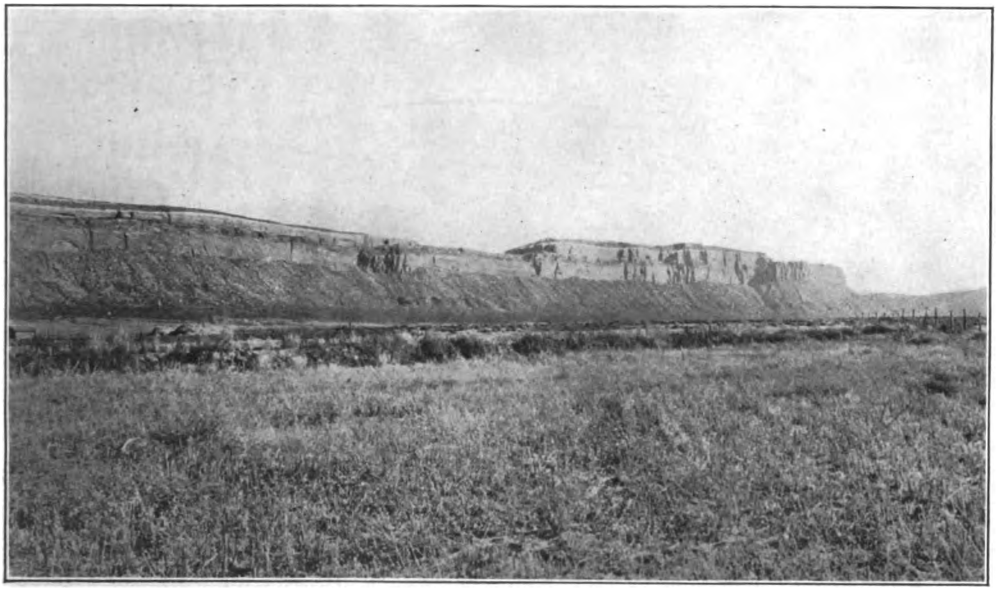
TABLE II (Rutherford, page 518)

RADIUM SERIES

Radium series	Atomic weight	Weight per gram of radium	Half-value period	Radiation	Range of α rays at 15° C.
Radium	226	1 gr.	2000 yrs.	α+slow β	3.30 cms
↓ Ra. Emanation	222	5.7×10^{-6} gr.	3.85 days	α	4.16 "
↓ Radium A	218	3.1×10^{-9} "	3.0 mins.	α	4.75 "
↓ Radium B	214	2.7×10^{-8} "	26.8 mins.	$\beta+\gamma$	—
↓ Radium C	214	2.0×10^{-8} "	19.5 mins.	$\alpha+\beta+\gamma$	6.57 "
↘ Ra. C^2	—	—	1.4 mins.	β	—
↓ Radium D	210	8.6×10^{-3} "	16.5 yrs.	slow β	—
↓ Radium E	210	7.1×10^{-5} "	5.0 days	$\beta+\gamma$	—
↓ Radium F	210	1.9×10^{-4} "	136 days	α	3.77"

The facts here tabulated, although beyond mental conception, are known with far greater certainty than many scientific facts often taken for granted.

In most uranium minerals the amount of radium present is represented by one part of radium to three million parts of uranium. The half life of uranium, or the time within which one half of any given quantity of the element will disintegrate into other materials, is about

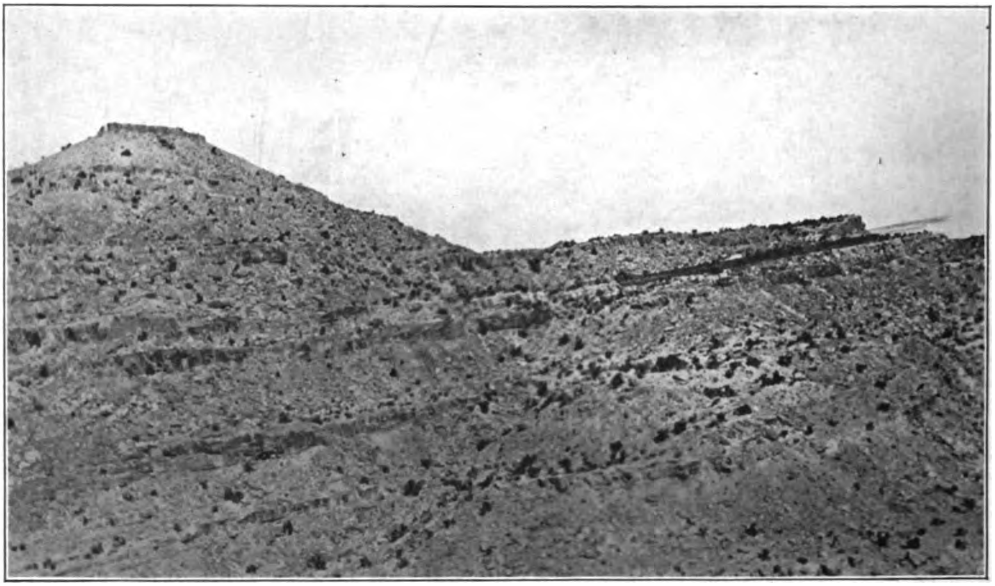


East Side of Parador Valley

five billion years; while ionium, the immediate parent of radium, has a half life of 200,000 years; and radium itself a half life of 2,000 years. Accordingly, it will be seen that, although the energy given off by these elements in ordinary periods of time may appear inexhaustible, it is not really so. Table II shows how radium is continually disintegrating and indicates that the material which we ordinarily speak of as radium is really a mixture of radium with the disintegration products enumerated in this paper. Many lectures would be needed to describe all the scientific aspects of the subject. A few of the more important facts only can be mentioned here.

Already some sixteen elements have been positively identified which result from the progressive breaking down of uranium and its decomposition products. One metric ton or 1 billion milligrams of uranium contains, when in equilibrium with its disintegration products, some 25,000 mgs. of ionium; 312½ mgs. of radium; 2/1000ths of 1 mg. of emanation; and 7 millionths of a mg. of Radium C. As already stated, these radio-active elements, and others not here enumerated, have been identified and studied almost wholly through the unprecedented amount of spontaneous energy they evolve. This energy is so intense that it is possible to measure the amount evolved by one fifty-millionth of a mg. or one three-thousand-millionth (1/3,000,000,000) of a grain of radium and even a very much smaller amount can be detected. These figures, of course, are in themselves incomprehensible, but if a piece of radium as large as a grain of wheat were divided among the inhabitants of the earth it would be easy not only to determine whether each individual had his portion but also to measure the radium he possessed.

One gram of radium in equilibrium with its disintegration products gives off 133 calories of heat per hour; or, in other words, sufficient heat to raise in approximately three-quarters of an hour, its own weight of water from the melting to the boiling point. During the full life of the element it would accordingly yield 3,700,000,000 calories. Of this energy, nearly three-fourths is evolved by the decomposition of the first product of radium which is a gas of the helium



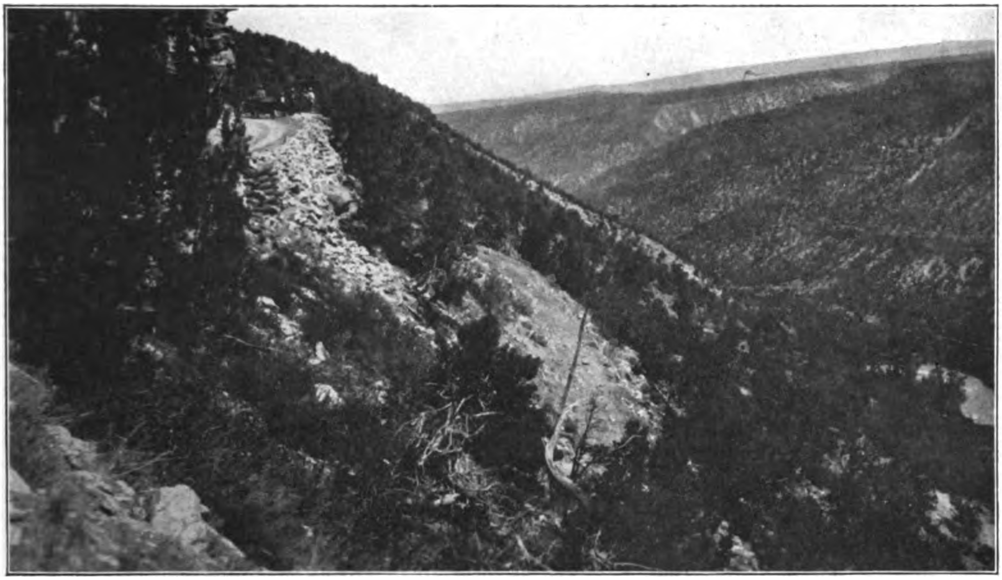
Utah Carnotite Country

argon group and is known as radium emanation, or niton.

It would require a half ton of pure radium to yield a single pint of this gas, but, if obtained, no material is known which would not melt instantly if used as a container.

The energy from these radio-active elements is manifest in three forms of radiation, known as the alpha, beta, and gamma rays. Radium itself gives off only alpha rays, but when, thirty days after separation from solutions containing it, the radium has reached a state of equilibrium with its dissociation products, the mixed material, which in commerce is known as radium, yields all three kinds of rays. I shall now consider these rays briefly.

The so-called alpha rays are simply positively charged atoms of helium thrown off with a velocity varying from some 8,000 to 12,000 miles per second. This is over two hundred times as fast as the swiftest flight of the next fastest material thing known in space, *i. e.*, a shooting star. On account of the mass of the helium atom and the rapidity of its flight, the alpha rays carry with them over 90 per cent. of the total energy evolved. They apparently pass through all other atoms and molecules that come within their path, but of the three rays given off by radium they are the least penetrating, being stopped by some 3 cm. of air or a comparatively thin film of any ponderable matter. They have only about 1/100 of the penetration of the beta rays and 1/1,000 to 1/10,000 of the penetration of the gamma rays. The study of these alpha rays has thrown much light on the constitution of the radio-active elements and on that of some of the other elements as well. By the loss of an alpha ray or helium atom, (atomic mass, four) the atom remaining is changed to another element having an atomic mass four units less than its parent and chemical properties which place it two groups to the left in the ordinary periodic scale. The alpha ray carries with it not only the helium atom, but also two charges of positive electricity, so that the valency of the resulting element is diminished by two. The energy of the alpha rays is so great that, by at least two distinct and separate methods, it has been possible to actually count



Gateway to Carnotite Country

these positively charged helium atoms as they are expelled one by one from radium. So that it is known that a single mg. of radium (or approximately 1/10 the weight of the ordinary pin head) expels, every second, 136 million alpha particles. Indeed, the counting of atoms of more than one form of matter is now done with such precision that, as stated by Prof. R. A. Milliken (*Science*, Vol. 37, page 119), scientists can now count atoms as accurately as one can count the inhabitants of a large city. It is hard to conceive that a single milligram of radium can continue to give off these millions of atoms per second for many thousands of years without complete disintegration, but such is actually the case.

The beta rays are negatively charged particles of electricity or electrons. They have approximately 1/1800 of the mass of the hydrogen atom and the velocity of the different beta rays given off by the different disintegration products varies greatly. Their average velocity is from 40 to 80 per cent. of that of light (185,000 miles per second), but some go as fast as light. They have approximately one hundred times the penetrating power of the alpha ray but are stopped by a few millimeters of lead or by proportionately greater thicknesses of less dense material. These beta rays are analogous to the cathode rays, but have much greater velocity than the cathode rays themselves. The loss of a beta particle from an atom of any one of these elements does not sensibly affect the atomic weight of the new element formed, but does increase the valency of the element by 1, so that the new element produced by the loss of a single electron has chemical properties which place it in the periodic table one group to the right.

The gamma rays of radium are perhaps the most interesting of all, although they carry with them comparatively little energy. They have recently been definitely shown to be light vibrations, having a wave length almost infinitesimally small. To speak in comparative terms, they are probably light, having a wave length perhaps 1/100 of that of the X ray, which itself has a wave length about 1/10,000 of that of ultra violet light.

The gamma rays are especially interesting and important, for the reason that,

perhaps because of their great penetrating power, they are the chief effective therapeutic agent in the radium treatment of cancerous growths. The gamma rays are emitted almost entirely from the decomposition product of radium known as Radium C. When I show you by convincing lantern slides, as I shall in a few minutes, the results obtained in the treatment of cancer, it will be hard for

A Carnotite Discovery

you to realize that these results were produced by the gamma rays from less than 2/100,000 of a single mg. of this remarkable element, which, although never seen by human eye, exists beyond the possibility of doubt.

The radio-active elements are studied, their quantities determined, and effects measured, chiefly by means of an instrument known as the electroscope.

This brief summary, stated in language intended to be illustrative rather than scientific, may give you an idea of the element which has attracted so much attention. At present the European nations are competing for supplies of this element at prices that, because of scarcity of the material, are almost fabulous.

Radium was first produced from the pitchblende ores of Joachimstaal, Bohemia, but these have failed to yield radium enough for even European use. In fact the radium ores have become so valuable that the Austrian Government owns the deposits and has forbidden by law the exportation of this ore. Consequently, radium ores are being sought all over the civilized world, and wherever prospectors go. They have not been found in really large quantities in any locality. Besides the pitchblende from Austrian deposits, a few tons of pitchblende concentrates are now obtained each year from the old tin mines in Cornwall. Some autunite, a beautiful uranium phosphate, is produced from Portugal and from Australia. Carnotite, a complex vanadate of uranium, is known to exist in Ferghana, Russian Turkestan. It is being mined in Australia and treated by a plant in Sydney that has a present yield of some 150 mgs. of radium per month. It can, however, be definitely stated that no one of the foreign deposits compares in extent or richness with the carnotite ore fields of Colorado and Utah.

In 1912 the United States Bureau of Mines established a laboratory in Denver and sent experts into the field to study the rare metal problems of the West. One of the first things ascertained was that carnotite was being mined and shipped abroad from the Paradox Valley in Colorado and few persons realized why it was being exported. It is now well known that the ores mined and shipped from American deposits during the last three years have yielded much more than half of the total radium production to date. This last

View from Mouth of "Black Fox Mine," Bull Cañon, Colorado

year over three times as much radium was taken from American deposits as from all other sources combined. In spite of these facts there is today available to American hospitals less than 1½ grams of radium element. German hospitals, on the other hand, are known to have acquired or contracted for 15 to 16 grams of radium bromide since June, 1913, to be paid for mainly by state and municipal appropriations.

During 1912, practically all of the ore mined in America was shipped abroad. In 1913 an American company with headquarters in Pittsburgh, Pa., began to produce and market radium, and to January 1, 1914, it had produced 1,350 mgs. of the element and had shipped to its plant a little less than one-half of the carnotite mined in this country last year. More than half of the probable 1914 output of this concern has already been contracted for abroad. These facts, and the great need of radium in American hospitals, has led to bills being introduced in Congress to give the government a preferential right in the purchase of ore mined on government land, and to provide for the extraction and purification of radium from the ores so purchased. Unfortunately, while these bills were being debated in committee hearings, practically every known public deposit of the material was staked either by prospectors or by corporations interested.

American carnotite is found chiefly in Montrose and San Miguel counties, Colorado, and in that part of Utah, northwest of these counties. The Utah deposits are at Green River, Table Mountain, Richardson, Fruita, Moab, and some sixteen miles southeast of Thompsons. The ores of these deposits are of lower grade than those of the Paradox Valley, but they are nearer to railroads and subject to lower transportation costs. The Green River deposits have apparently become regular producers. In Colorado, prospects have been opened at Coal Creek, fourteen miles north of Meeker, and at Skull Creek, sixty-five miles west of Meeker; but the richest of carnotite deposits in America and indeed the richest known radium bearing region in the world is that of the Paradox Valley, Colorado, which extends from Hydraulic on the north to the McIntyre District on the south.

In the Paradox region, the deposits seem to lie invariably just above the fine grained La Plata sandstone. This rock is usually exposed high on the sides of the canyons, some of which are excelled in extent and in natural beauty by only the Grand Canyon itself. In a few instances, as at Long Park and Club Ranch, the deposits are only a few feet under the surface, the higher formations having been eroded; but the stratum in which the carnotite occurs, when not entirely eroded, is deep below the surface of the mesa. Accordingly, prospecting is mainly carried on along the sides of the canyons; where vanadium and uranium stains are seen upon the rock, the prospector blasts his tunnel, in the hope of finding a pocket of the ore. The fact that the ore occurs in pockets renders prospecting uncertain, and there appears to be no present hope of insuring a successful search for pockets that are not exposed or do not happen to be near the surface. Although it is probable that many pockets of carnotite occur in the same geologic horizon, their discovery, except where the ore-bearing stratum has been exposed by erosion, appears at present to be an almost hopeless task. The eroded sides of the canyons have been prospected again and again, but new claims are still being opened and are being sold by the prospector to the large companies or operators who mine the ore. In such a sale the prospector and the purchaser both take a decided risk, for at present no method is used to determine the extent of the ore in the pocket other than the "prospector's hole."

There are two important ores of radium found in this country, carnotite and pitchblende, although carnotite is by far the most important, and more radium has already been produced from this ore than from all other ores put together. Carnotite is a lemon-yellow mineral and is usually found in pockets in sandstone. It may occur as light yellow specks, disseminated through the sandstone, or as yellow incrustations in cracks; or it may be more or less massive, associated with blue, black, or brown vanadium ores. Pitchblende, on the other hand, is a hard, blue-black ore that looks like magnetite, but is heavier. It is found in pockets and veins of igneous rocks. It is not nearly as widely distributed as carnotite. Either one of these ores may be easily identified and a rough estimate of its uranium content determined in a few minutes by means of the electroscope; or, if an electroscope is not at hand, the radio-activity may be proved through photographic methods. All that is necessary is to wrap in the dark a photographic plate in two or three thicknesses of black paper. On the paper, lay a piece of thin metal with sharp outlines such as a key or clock wheel, and just above this object suspend two or three ounces of the ore. Place the whole in a light-tight box for three or four days. If the plate is developed in the ordinary way, and the ore is appreciably radio-active, a sharply defined image of the key or other object will be found on the plate.

The foreign manufacturers have agents and buyers in America and most of the rich claims are now in the hands of three or four corporations, but so far as the hearings before Congress are concerned, they have worked together almost as a unit in an effort to defeat the proposed legislation. In spite of the humanitarian standpoint involved, this is perhaps not to be wondered at, when it is considered that the best authorities believe that the present cost of manufacturing radium is scarcely more than one-fourth of its selling price.

Most of the ore deposits are in a desert region and are many miles from the nearest railroad. In the Paradox Valley, which is by far the richest radium-bearing region of the world, the ores have to be hauled by wagons forty to seventy miles to the nearest railroad station and the ores from many claims have to be packed on burros some miles to the nearest point to which roads can be built. The cost of mining, and especially of transportation, is therefore an important factor in the marketing of carnotite.

The Green River, Utah, deposits have a distinct advantage over the Colorado

Entrance to "Yellow Bird Mine"

deposits in regard to freight rates, as they are nearer to the railroad, but as their ores do not average as high in uranium, this advantage is more apparent than real. The present costs of mining, sorting and sacking in the Paradox apparently vary from about $28 to $40 per ton. To this must be added $18 to $20 for the haul to Placerville, and, in most instances, an additional charge for burros from the mines to points that can be reached by wagon. The freight rate from Placerville to Hamburg, via Galveston, is $14.50 per ton, so that the average cost at present to the miner of laying down his ore at the European markets approximates $70 per ton. The selling price varies with the uranium content, but is by no means proportional thereto, since a premium is always paid for rich ores. Very recently, however, a decided improvement has taken place and for ore containing 2 per cent. uranium oxide, the price, delivered in Europe, is now about $2.50 per pound for the oxide, an allowance of about thirteen cents per pound being made for the content of vanadium oxide, so that the 2 per cent. ore delivered in Hamburg brings about $110 per ton. One and one-half per cent. ore is now salable, but unless this ore is taken from the dump so that the mining cost may be disregarded, it will scarcely bear even present transportation charges from the Paradox, although such ore probably will soon be shipped regularly from the Utah field.

A price of $110 at Hamburg for 2 per cent. ore leaves a good margin of profit to the miner, as mining profits go, but when one considers that this price represents only a little over one-fourth of the value of the radium content of the ore, and that from this fraction of the value the American miner has to meet the outlay represented by the investment, by mining costs, transportation and assay costs and by losses in transit, it seems scarcely just that nearly three-fourths of the value should go to foreign manufacturers of radium, especially if one remembers that radium can be produced much more readily from carnotite than from pitchblende. There are two ways of reducing this difference between the actual value of the ore and the price that the miner receives. One is for the producer to hold American ores for a higher

price, and the second is to manufacture radium under Government auspices.

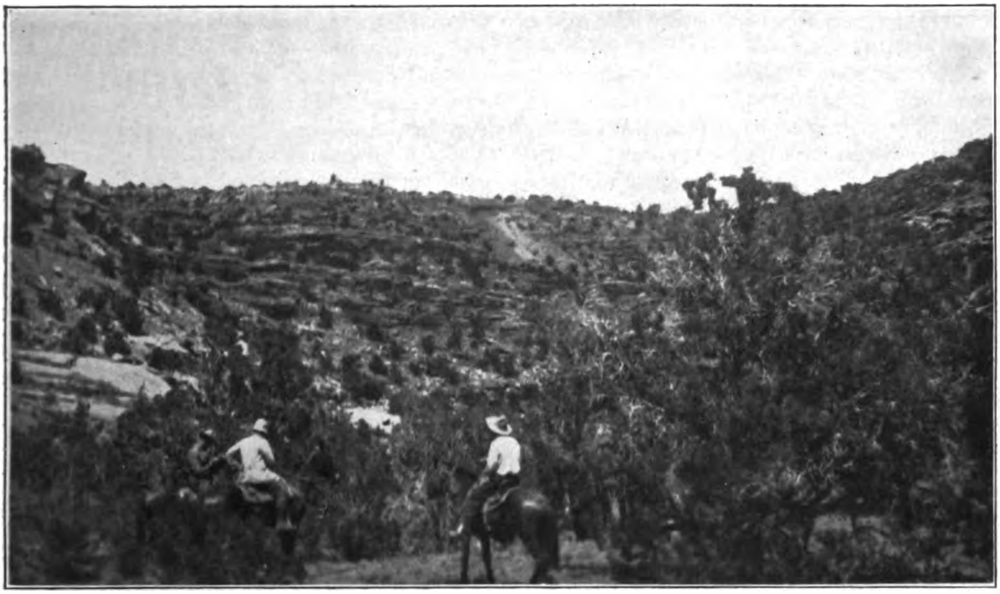
One of the most important features of the whole problem is the saving of the present wastes. For every ton of high grade ore that is taken from the mine, at least four tons, and probably more, of low grade ore are left on the dump. Some of these dumps will be later worked for their radium, but in many of them the low grade ores have already been so mixed with gangue material that profitable separation is practically hopeless and in addition much fine ore has been blown away by the winds or washed away by the rainfall of the short rainy season. As a result twice as much radium is wasted as is being produced.

There is now some prospect that through the activities of the Bureau of Mines these low grade ores in future will be carefully stored and it is also probable that concentration plants will be soon in operation—thus preventing some of the losses. In any case, mechanical concentration is inefficient,—and distance from the railroad makes chemical concentration at present impossible. Mechanical concentration probably can, however, save at least one-half of the material now going to waste.

The price of radium is now approximately $120 per mg. of radium element in radium bromide of 60 per cent. purity. In bromide of 90 per cent. purity the price is as high as $180 per mg. and foreign governments have paid even much higher prices than this. A price of $120 per mg. does not mean that the material is bought in the elementary condition, but that the radium chloride and radium bromide, now on the market, are paid for on the basis of the metallic radium they contain. This price of $120 per mg. of element is equivalent to approximately $91,000 per gram of radium chloride or $70,000 per gram of anhydrous radium bromide. Whether these prices will rise, fall, or remain stationary cannot be predicted. The production of radium is sure to be larger and meso-thorium is coming on the market in increasing quantity. On the other hand, the supply of radium-bearing ores is limited and no large resources are in sight. The most favorable estimate made by any of the employees of the Bureau of Mines who have been through the American carnotite field is that the known deposits do not warrant the assumption that as much as 200 grams of radium element will ever be produced from that field.

Several radium institutes have been founded throughout the world for studying the application of radium to science and to disease. Some of these are public and some private. Prominent among them may be mentioned the Radium Institute of Austria, founded under a donation given by Dr. Kuppelweiser to the Academy of Science of Austria, which now has one of the largest supplies of pure radium salts used chiefly in scientific investigations. In Paris, a new radium institute under the direction of the Sorbonne has been built by this university near the Pantheon. In England, the London Radium Institute was founded by Sir Ernest Cassel and Viscount Iveah, who gave a large sum for its endowment. This institute is making a special study of the application of radium to disease.

In this country, the National Radium Institute has recently been founded by Dr. Howard A. Kelly of Baltimore and Dr. James Douglas of New York City, and I am fortunate in having been connected with the work of this institute since its inception. When it became known through the investigations of the United States Bureau of Mines, in the latter months of 1912, that valuable radium ores were being shipped abroad to be manufactured into radium and sold back into this country at prices entirely incommensurate with those paid for the ores themselves, it was deemed necessary to take prompt action to insure at least a portion of this radium being available to the people of the United States under such conditions as would prevent it from being altogether a rich man's remedy. The matter was called to the attention of Doctor Kelly and Doctor Douglas, both of whom were known to be deeply interested in radium for use in two hospitals with which they were



Cliff Mine, "Saucer Basin," showing dump containing many hundreds of tons of wasted ore

closely connected, and they immediately favored the formation of an institute to extract radium from American ores and to keep the radium in this country. It was agreed, if the ores could be procured, that the radium institute would be founded and the necessary funds furnished to work up the raw material. Through the active interest of the officials of the Crucible Steel Mining and Milling Company, sixteen claims containing carnotite, in Montrose County, Colorado, were leased on a royalty basis under an agreement providing for the return of the uranium and vanadium content of the ores to the owners of the claims, and the National Radium Institute was founded. As the Denver office of the Bureau of Mines had been carrying on laboratory experiments and field investigations with reference to uranium ores, and the Bureau had published a bulletin covering these investigations, the institute proposed a coöperative agreement, whereby the Bureau was offered an opportunity for studying the mining and concentration of the carnotite ores, and the most practical and least wasteful methods of obtaining uranium, radium, and vanadium therefrom. Under the agreement, the chemical management of the mines and mills is to be guided by the scientific staff of the Bureau of Mines. One hundred and twenty tons of high grade ore have already been procured; the mill has been built, and began to treat ore on March 18. It is believed that this agreement will assist the prospector and the miner, by providing a greater demand for his ore, and, by aiding to reduce the great wastes which now take place, will help the plant operator, by developing methods of treatment and by creating a larger demand for his products; and finally, will benefit the people by making available for use, in two American hospitals, at least four times as much radium as is now in the country. The radium produced will be used without profit to the donors, in the treatment of cancer and other malignant diseases. As you all know, the press of the country has been in an excited state for some two or three months over the application of radium to the cure of cancer. Much has been printed that had no justification in fact, but that the subject is of the utmost

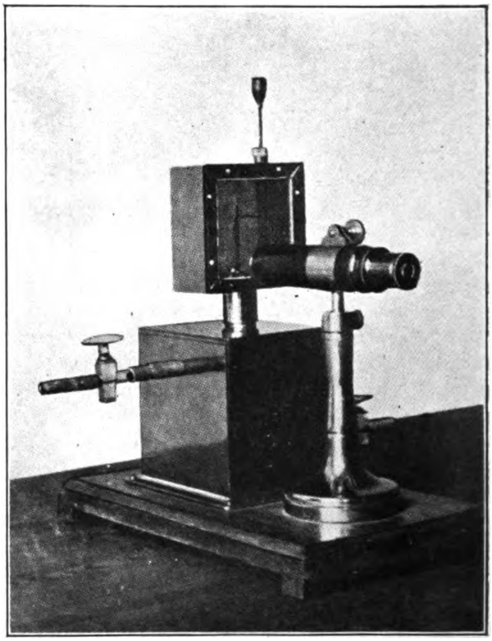
importance can be easily demonstrated. Reporters in many cases have claimed for radium much more than was even hoped by those most familiar with the subject; while, on the other hand, many eminent physicians have expressed disbelief in the efficiency of radium without having any personal knowledge whatever of its application. There are today, in this country, only two or three centers where sufficient radium has been experimented with to entitle the experimenters to express an opinion from personal experience as to its efficacy.

At the hearings in Washington before committees of Congress, Dr. Robert Abbe of New York, who had some 350 mgs. of radium bromide, reported cancer cures of eleven years' standing and that Dr. Howard A. Kelly and his associate, Dr. Curtis F. Burnam, who had been working for some years with radium and had approximately 1 gram of radium bromide, reported cancer cures of five years' standing, without recurrence, including cures of all forms of cancer—epithelioma, sarcoma, and carcinoma.

In spite of the fact that statistics have shown that there are 200,000 cancer patients in the United States, with an average of 75,000 deaths per year; that the chief of the Hygienic Laboratory in Washington stated before the Senate Committee that he had been convinced against his will of the efficacy of radium treatment in many cases of cancer; that the United States is producing some three times as much radium ore as all the rest of the world put together; that the ore to be conserved is on Government land; that Germany and France are not only purchasing American ores but are taking by far the larger part of the output of the one American plant producing radium; and that immediate action was necessary to insure any portion of the material being conserved to our people, the bills have not yet been acted upon in either the House or Senate.

In this connection the following quotation from a recent editorial in the *Washington Times* may prove of interest:

"Cancer is a poor man's disease. . . . Radium now selling at $120,000 per gram is a rich man's remedy. Hospitals which are charitable, and philanthropic institutions cannot afford to pay the price that is demanded for radium. . . . The deaths from cancer in the United States reach 75,000 each year or 200 every day. The contention of the Federal Government is that if a preferential right is given to it to purchase carnotite ores it will develop the entire field and smash the present monopoly, which is charging prohibitive prices for radium. The plea of those opposed is that the miner must be protected. That plea involved, in 1913, 150 miners and prospectors and is used as an argument against 200 deaths a day from cancer. In the sixty-five days of discussion there have been 13,000 victims of cancer and each succeeding day of delay there are 200 deaths, some of which might have been avoided if the Government had an opportunity to place radium in the different hospitals of the country.



Electroscope for determining the Uranium content of an ore

"Colorado has the greatest known deposits of radium bearing ores and these

ores are all on the public domain. Colorado has had the most wonderful humanitarian opportunity ever offered a state, and yet the selfish interests of a few people have so far blocked any attempt upon the part of the Federal Government, on its own property, to obtain for the victims of cancer a remedy which has been wonderful in its results."

Whether or not radium is invaluable in the treatment of cancer, and whether there is accordingly some justification for the editorial quoted, must be determined by the testimony at hand.*

Dr. Howard A. Kelly, Dr. Curtis F. Burnam, and Dr. Robert Abbe gave testimony before the Mines and Mining Committee of the House of Representatives of many cancer cures accomplished in the hospitals under their supervision. There is no higher authority in the country than these doctors. Their conclusions have been criticised chiefly by those who have read the much exaggerated newspaper articles as to their statements. So far as I have been able to determine, those who have visited their hospitals and seen the results of their treatment are convinced of the efficacy of radium in cancer therapy; and having carefully investigated the results of actual practice have been themselves convinced of its value. Criticisms from other physicians have been printed mainly in the public press, but, so far as I can ascertain, no one of these physicians has had the slightest experience in the use of a sufficient quantity of radium to entitle him to render judgment and they have frequently come to their conclusions from the statements of physicians who had only a few milligrams of radium or because certain cases of cancer, in prominent individuals that were in the last stages of the disease, were not cured. To judge from such data is much like condemning the statements of those who smelt iron in blast furnaces because blacksmiths cannot reduce ores commercially in their forges.

My own observation has led me to agree absolutely with the statements of Dr. John F. Anderson, director of the Hygienic Laboratory of the United States Public Health Service, as given on page 161 of the Hearings before the Committee on Mines and Mining, U. S. Senate, February 10–23, 1914.

"I have been forced to the conclusion, I may say, somewhat unwillingly, that the use of radium has a very important place in the treatment of malignant tumors. The greatest use at the present time seems to be in the treatment of certain forms of cancer, technically known as epithelioma, and in the treatment of another form of malignant tumor, technically known as sarcoma. These growths are external and can be readily gotten at and the radium can be readily applied to them. I think some of the discredit, if I may so term it, that the use of radium has been given, has been due to the fact that attempts have been made, first, with too small amounts to treat these various growths; and second, attempt to treat cases that are practically beyond any hope.†

"I think the profession, as a whole, has no way of judging the value of this other than by statements made by persons who have a sufficient amount of radium to work with. Up to this time, in this country, there are only two doctors who have had a sufficient amount of radium to work with, and therefore the only two whose results can be considered as showing what radium can do. They are Doctors Howard A. Kelly and Robert Abbe."

No person can have been in touch with some of the wonderful cures that have been accomplished through the use of sufficient quantities of radium in the hands of experts and not be convinced that we have at last obtained the greatest weapon so far discovered with which to combat cancerous growths.

*At this point, several lantern slides showing cancer cures were given but cannot be reproduced here.

†At this point Doctor Anderson presented several photographs of cancer cases which are reproduced in the record.

Jean Henri Fabre

Permission of the Century Company

JEAN HENRI FABRE

THE STORY OF THE GREAT NATURALIST'S STRUGGLES TO PURSUE HIS CHERISHED CALLING — HOW PUBLIC RECOGNITION FINALLY CAME TO HIM LATE IN LIFE

BY CAROLINE CHASE BIGELOW

JEAN HENRI FABRE was born at Saint Léons, in the Haut Rouerque, on December 22, 1823. From his autobiographical notes, we learn that his parentage was indeed poor and humble. At an early age, to make one less mouth to feed in the impoverished family, he was sent to Malaval to pass the early years of childhood in his paternal grandmother's care. Here he remained till he was seven, surrounded by the humblest people, uncultivated, unimaginative, yet showing, even in his childish fancies, the love of nature and the observing powers of the naturalist, which were to characterize his later career. He then was placed at a School in St. Léons (1830) kept by his godfather. Next, his parents placed him, when eleven years old, at the Collège de Rodez, (1833–35), where his services as chapel boy defrayed the cost of his tuition. His childish love and interest in nature grew stronger each day, and he became more and more eager to investigate her secrets.

Financial misfortunes followed, and the Fabres moved to Toulouse (1839). Henri studied gratuitously at the seminary of the Esquille, but, in a year, the family were moving again, this time to Montpellier. Here misfortunes seemed to descend with a dreary finality, and the future naturalist was obliged to drop his studies and earn his living with the sweat of his brow, even working on the road with a gang of day laborers. During this dark period his passion for learning never waned and his love of nature offered him continual comfort. Buoyed by this courage, even amidst all sorts of privations, he ventured to enter a competitive examination for a bursary, or position of pupil with some teaching duties to compensate for instruction received. Fortunately he was successful, and was accepted as assistant in the École Normale Primaire at Avignon. Here he was assured meat and drink, and also some time to give to his beloved study of nature. At one time he was spending so much time in this study, that he was reprimanded by his superiors and restored to favor only after such diligent work otherwise that he was nearly a year ahead of his fellow pupils. He was interested in other studies besides natural history, however, and realizing that his livelihood as a teacher could not be gained by the study of insects alone, he applied himself to mathematics and chemistry (though with no laboratory equipment), and was rewarded at the age of 19 by a superior diploma.

The College of Carpentras offered Fabre the position of primary teacher in 1842 on the mere pittance of about $150.00 a year. In spite of discouraging surroundings, however, Fabre's ambition kept him up with the hope that success here would mean a better position elsewhere. He taught his beloved sciences, and especially in chemistry, where he learned almost step by step with his pupils, did he have marked success. His spare moments were devoted to his natural history and he started a collection of specimens, insects, ferns, plants, rocks, in his little museum to be studied carefully as opportunity permitted. Two years after coming to Carpentras, his first marriage took place. He also prepared himself for further examinations, receiving from Montpellier two baccalaureates, and the license to teach mathematics and physical sciences. In possession of these various degrees, stamping him as a man of learning, Fabre hoped for a new position where he might have more

salary or devote all his time to natural sciences. He waited long, but at last he was offered the chair of physics at Ajaccio at a salary of $360.00, and he hastened at once to Corsica (1848).

Fabre's stay in Corsica extended over about five years, with one visit to the mainland because of illness. He intended to devote these years, apart from the hours demanded for his teaching, to the study of mathematics; but the wonderful beauty of the island, the luxuriant flora, the manifold treasures of the sea, captivated the poetic naturalist and, instead, he spent much of his leisure collecting and studying the thousand specimens which were ever before him. Here, also, he made two friendships which materially encouraged his studies along these lines. Requien, a then famous botanist of Avignon, visited the island, as did Moquin-Tandon, professor from Toulouse. Requien was an enthusiastic collector, with a wonderful memory for the masses of things observed; Moquin-Tandon, who was, in a way, the successor of Requien in the study of Corsican vegetation, went a step farther, laying stress on beauty of expression, and on the philosophy of life as expressed in the creations of nature. Such influence fell on fertile soil in the mind of the young Ajaccio professor. To quote Fabre's own words, never again should he sit at such an intellectual feast as that. "Leave your mathematics," said Moquin-Tandon to him, "no one will take the least interest in your formulae. Go to the beast, the plant, and if, as I believe, the fever burns in your brain, you will find men to listen to you."

From Corsica, Fabre was called to teach in the Lycée at Avignon, 1853. Encouraged by this new appointment, he allowed himself to hope he might yet teach in the higher grades, and, in preparation for this, he obtained a third diploma, this time for the teaching of natural sciences (1854). The twenty years of service at Avignon which were now to come, brought him, unfortunately, no higher academic ranks, and when he finally quitted the work of teaching he stood no higher than when he was at Corsica. These years, however, were ones of great activity and were those which definitely worked out the course of the naturalist. At the end of the period he was thoroughly started on the line of work in which he excelled.

Meanwhile his salary had fallen to but $320.00 a year, while his family had increased, so that each day there were seven to be provided for. Hence Fabre was obliged to take private pupils or any other work which presented itself, so great was the need for more income. Yet in spite of these cares, he was at this time engaged in an important piece of work. Soon after his arrival at Avignon, a volume of León Dufour had come under his observation, and suggested to him that minute, careful, personal experiment and observation was a field in which he might realize the heights of his desires. Réamur and the two Hubers had undertaken similiar work. As the first fruits of this inspiration, he published, in 1855, in *The Annales des Sciences Naturelles*, "The Memoirs of the Great Cerceris" (a wasp). The same year he presented himself for a doctorate in Paris, trusting that such a degree would eventually reward him with university connections. The thesis in zoölogy dealt with the Myriapoda, that in botany, with the singularities of a strange family of orchids; neither work contained any strikingly original material.

Two years after the paper on the wasp, Fabre published (1857) a second masterpiece, his observations on the beetle. The Institute had recognized his ability by granting him a prize in experimental physiology, 1856. For a time, his financial status, too, improved, as the Lycée appointed him drawing master (1857), and the city made him curator of the Museum and, soon, museum lecturer, thereby adding about $240.00 per annum to his slender income. In spite of these additional salaries, Fabre was continually confronted with the problem of securing sufficient income to meet the demands of life, and at the same time of giving himself leisure for study along his special lines. In his desperate searches for a solution to this problem, it occurred

to him that the growth of madder, plentiful in the region, might have great commercial advantages as a dye product. He threw himself into this work, and spent some years devising means of manufacturing dyes, but when success seemed almost on the horizon, the synthetic manufacture of madder dyes was taken up by others, with greater commercial values. All Fabre's efforts in these lines served but to give a few useful points to those who were to reap pecuniary results in the field where he had aspired to be first.

The hopes of a comfortable future, with a fixed income from this source, being dashed, Fabre began to add a penny now and then to his earnings by writing text-books, although his duties at the school were often so laborious, that he had scant time for other activities. To this period, belongs the acquaintance of two men who are well known enough to merit a word of mention. In 1865 Pasteur visited Fabre, having been referred to him as an authority in entomology. The hauteur of Pasteur towards the teacher at Avignon seems rather unwarranted and the visit did nothing to encourage a friendship between two men who might have had much in common. Far different was the attitude of John Stuart Mill, whom Fabre met at the Requien Museum. The two men met on the common ground of love for natural history and formed a friendship which, in one instance surely, was of the greatest value to Fabre.

Fabre now undertook, along with his municipal lectures, a series of free conferences in the ancient Abbey of Saint Martial. The burden of these courses was that many subjects, hitherto never proposed, might be taught to both young boys and young girls alike, and that natural history was a book which all might read and which had a fascination totally hidden by the tedious methods of university teaching. These wonderful discourses were, however, to aid in the undoing of the great leader, for the devout churchman and the pedant alike cried out against such truths, such heresy in presenting science to the young, such a position for one so humble to take. His colleagues from the Lycée failed to support him, and his dear friend Duruy, high in Paris educational circles, had himself fallen, because of clerical opposition. Harassed by this petty criticism, the end of his endurance was reached when he was denounced from the pulpit as a dangerous man. Then, at this moment, his landlady became, as it were, a tool of his enemies, and told him he must quit his dwelling at once. The poor man had absolutely no money to move to a new house, and not a friend at Avignon from whom he might ask help. Even the small income from his text-books had fallen away because of the war. At this crisis he turned to his friend, Mill, and waited not long for a reply. Mill lent him gladly a generous sum, and with this, Fabre severed his connection with the Lycée, and shook the hateful dust of Avignon from his feet. This was in 1871, and he established himself at Orange.

We now enter upon the last division of Fabre's life, the time devoted to science apart from any academic connection, and we may further divide this time into two periods: the life at Orange and the years at Sérignan, a suburb of Orange. Fabre lived at Orange about six or seven years, and to meet the demands of support for his family, he devoted himself almost unceasingly to the writing of text-books while there. The old text-books had been dry, unadorned information; now, to quote Legros, "What a contrast and a deliverance in these little books of Fabre's, so clear, so luminous, so simple, which for the first time spoke to the heart and the understanding; for work which one does not understand disgusts one." Such charm, all the same, did not always attract the public, and the income of the scientist was often far too small to supply his needs. Meanwhile he was also working on the book which had been for twenty-five years his desire to publish, and in 1878 appeared a collection of studies under the title of the first volume of the Souvenires Entomologiques. The days at Orange were also marked by three events which greatly saddened the harassed Fabre: his good friend, Mill, passed away, his oldest son, too, died, and he was

suddenly dismissed from the post of curator at the museum, the tender care of whose collections had been a great joy and comfort. (1873.)

In 1878, Fabre removed to Sérignan where he was able, primarily from the income of his little text-books, to purchase his home, dilapidated though that home was indeed. Henceforth he would be saved the pain of an unpoetic landlord, such as the one at Orange, who ruthlessly trimmed the beautiful plane trees in front of the cottage. For a period, at least, his books brought him in enough to exist in the simplest way, and to indulge himself in the cultivation of his little "terrain" as pleased his fancy, particularly the fostering of insect life. Not long after the removal to this scene of comparative comfort, sorrow came to Fabre again, with the death of his wife. Two years taught him the difficulties and loneliness of life alone, so he remarried, choosing a young and capable woman for his second wife. Three children were born of this union. Henceforth the life of Fabre may be outlined briefly, his attention given to his cherished studies, his life one of retirement, his home circle congenial and interested in his pursuits. While his text-books sold, the royalties on them were sufficient to keep the family, but when, after ten years of popularity, the sale fell off, poverty again stared Fabre in the face. The scientific reputation had come among biological professors, and within learned societies, the Institute had made him a corresponding member in 1887. Such people as Rostand and Maeterlinck were reading his work with due appreciation, but such fame does not provide meat and drink. By 1894, he was sore pressed for funds, and for some time the sole assured income was $600.00 given him by the Institute as the Geguer Prize. In 1899 he received the Petit d'Ormoy prize of $2000.00 from the Institute. In 1908 the stress was so great he endeavored to sell the collection of beautiful drawings he had made in life size of all the fungi of Provence. He consulted the poet Mistral on the disposition of this most treasured possession. The poet, touched by such pitiful circumstances, exerted himself actively in Fabre's behalf and finally succeeded in acquiring from the government a small pension of $300.00 per year for the aged man. It was then that his pupils, and a few others who knew him for what he really was, decided to celebrate his jubilee, hoping to attract a little public attention to his wonderful work. The celebration was on April 3, 1910: open house was kept at the modest dwelling, the garden, the Harmas so charmingly described in an essay, was opened to all, and visited by many; a banquet was held, and greetings from a host of famous men received. A golden plaque was made and presented to the poet scientist. Thus at last twilight was shed on the end of a beautiful day, and the aged scientist, though feeble, is now sought by many, some, in truth, inspired by curiosity, but others earnestly desiring to pay homage before it is too late, to this remarkable figure. Fabre feels he has not lived in vain, and that he has aided in opening the doors of the beauties of nature to many.

Now that Fabre has become a famous person, people are reading his books, criticizing his theories, judging his style. In the first field there is material in abundance, for we find fully eighty text-books, ten volumes of the Souveniers Entomologiques, and, of these, numerous translations. Various essays dealing with the same subject have been grouped together by translators and published under such titles as "The Life of the Fly," "The Life of the Spider," "Social Life in the Insect World." His power of accurate observation is very great and, as a scientist, he has been considered by some as second only to Réamur. His philosophical position was a distinct refusal to recognize evolution as a legitimate idea. The problems of instinct to which Bergson has called attention were opened up by Fabre, but he is considered by some too rapid in making deductions from his observations. John Henry Comstock says, "Beyond some descriptive criticism of the theory that instinct is inherited habit, modified by struggle for existence through countless generations, there is little in his work which helps us to solve

the problem of the essential nature of instinct. He has accumulated the bricks but has not erected the building."

Whatever may be the criticisms of other scientists of the theories Fabre lays down, they, and all the world else, are in accord in praise for the language and the style in which these ideas are conveyed to us. Maeterlinck calls him the Insect's Homer; Rostand affirms "he thinks like a philosopher and writes like a poet"; Bergson draws largely on his ideas and illustrations of insect life to make his own philosophy attractive. Fabre is untechnical in word, full of imagination; he portrays the living insect as it really is, clouded in a veil of poetry and romantic charm. He feels a personal friendliness for the little things he describes with such purity and grace of expression. He has taken the science of Nature from the hands of the mere observer and reasoner, and glorified it in the soul of the Poet.

References: *Review of Reviews*, May, 1913; *Outlook*, February 15, 1913; *Literary Digest*, October 18, 1913, Article by J. H. Comstock; Legros: Fabre the Poet; J. H. Fabre: Life of the Fly (Translated).

GOOD SOIL FOR COLON BACILLI

Charles Leon Cowles, a student in the Department of Biology and Public Health, at the Massachusetts Institute of Technology, has been investigating means for detecting the presence of bacillus coli in water. The position with regard to the identification of the bacilli is that they all look much alike and, to tell the difference between them, it is necessary to apply some other tests. Stains, resistance to acids and the ability to produce gas are among the methods of determining the species. Another way is to find foods or soils in which some particular species will grow. Of this kind of test, the mixing of lactose bile, obtained generally from the organs of oxen, has been a means of distinguishing between the B. coli and others, the medium being favorable to the growth of this particular bacillus.

The B. coli is an intestinal organism of man and its presence in water may be termed the red flag for typhoid and other diseases, and like the innocuous red flag at the railway crossing is a warning of a great danger. It is important, therefore, to gain some quick and reasonably accurate means of determining the presence of B. coli in domestic water supplies. The ordinary test with lactose bile media is not considered very delicate, in fact some authorities have pronounced it only twenty per cent. efficient.

What Mr. Cowles has done is to add one to two per cent. of bicarbonate of soda to the medium with the result that the B. coli grows rapidly and other forms slowly, besides which the soda will prevent the growth of moulds and spreaders, the latter quick-growing things that come perhaps from the atmosphere and cover and obscure the plate. The whole story, which already bears useful results, is but a report of progress, and is suggestive of the untouched fields for investigation that are here waiting for the biologist.

AERONAUTICAL INDUSTRY IN FRANCE

To show the magnitude of the aëronautical industry in France, the following information for the year 1913 has been compiled by the "Aero Club de France":

Spherical Balloons—		
Ascensions	837	
Passengers carried	2,290	
Hours duration aloft	4,640	
Pilot certificates granted	87	
Dirigibles		
Ships built	7	
Total power	2400	
Voyages	165	
Distance	15800 Km	
Hours duration aloft	345	
Passengers carried	1029	
Pilot certificates granted	29	
Aëroplanes—		
	1913	1912
Aeroplanes built	1148	1428
Sea planes built	146	—
Distance covered, km	13040000	5000000
Hours aloft	133800	39000
Cross country flights	23600	9100
Passengers carried	47900	12200
Pilot certificates granted	384	489
Aëroplane Motors .		
Total power mounted in French aëroplanes	89,000	
Total power manufactured and sold	228,836	

J. C. H.

ADAPTATIONS OF CROPS TO SOIL

ENORMOUS RETURNS FROM EFFICIENT FARMING BASED IN A LARGE DEGREE ON PHYSICAL AND CHEMICAL RELATION OF SOIL TO CROPS

BY GEORGE E. STONE

THE greatest advance in knowledge concerning the adaptation of crops to soils has been achieved through practice and experience rather than by means of field and laboratory studies of the soil. There are many conditions aside from the surface texture which play a part in this adaptation, such as the nature of the substratum, depth of water table, etc.; and some insight into the subject may also be had by studying the distribution of plants, as given in any flora. Of course New England has been settled for some generations and deforestation and agricultural pursuits have been carried on extensively so that we find many changes in our soils and consequent modification of the flora. Some of the many factors determining the distribution of plants are complex and difficult to eliminate from other factors, and at present not enough is known about them to determine their real significance.

On soils which only a half century ago supported certain types of vegetation we now find an entirely different flora owing to changes in the nature of the soil; lack of humus contributing largely to this modification. Some plants, such as the Canada thistle, were more common forty years ago in Massachusetts than at present, while some other plants which have grown here for some time under cultivation have recently escaped and become pests. It would naturally be supposed that this is due to a change in the environment, soil conditions or source of seed. But whether there is in plants as in races of men, a tendency to aggressiveness which, usually lying dormant, sometimes unaccountably breaks out, we will not venture to say; still there is some evidence to support such a theory.

Some plants are confined to bogs, some to sandy soils, and others to heavy, compact soils, and many are adapted to a great variety of conditions. Others are limited to salt marshes, and still others to territory within a few miles of the seacoast. Elevation, humus and soil moisture play an important rôle in plant distribution, and some plants are restricted by what is termed "seed habit," the seeds of some species retaining their germinating capacity for some time and others for only a few weeks or even days. For instance, the seeds of the willow, poplar, alder and other species native to wet locations remain viable only a few days or weeks, while others will do so for ten to twenty-five or more years. Seeds with a limited term of viability must therefore find suitable conditions for germination during this time, while the others can afford to await their opportunity.

Most garden seeds require a minimum of 2 to 3 per cent. of soil moisture to germinate at all, and for the best germination a higher percentage is required; therefore during dry seasons the seeds of some crops fail to catch. Purslane and pigweed seed, however, will germinate with a very small amount of soil moisture and flourish when more desirable plants will not.

The percentage of air in soils plays its part in plant adaptation, as do also the chemical constituents and biological characters. The soil texture or mechanical properties, which are inseparably connected with the air and moisture of the soil, together with the capillarity, etc., are also very important factors in plant distribution as well as crop production. It should be stated, however, that the specific effect on plant distribution of any one of the factors mentioned is not

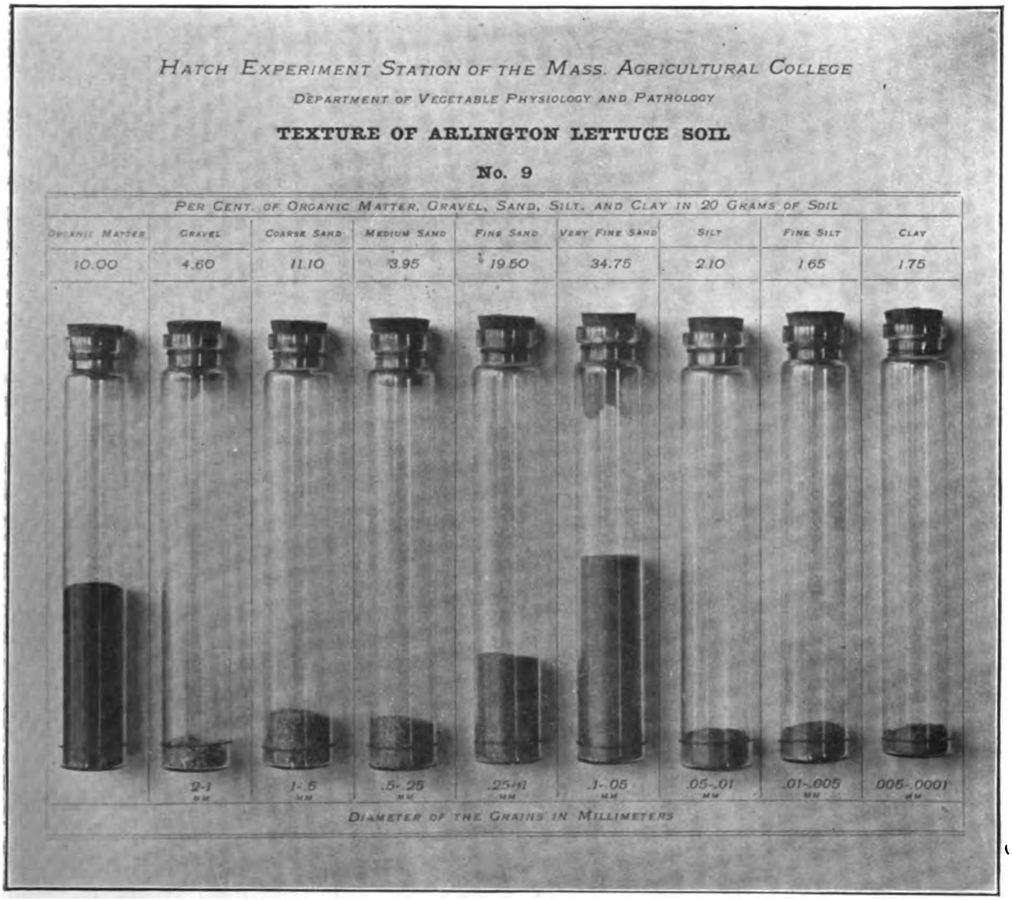


Figure 1

known; still a great deal is known concerning the effects of chemical constituents on plants, much more study having been given to this subject. Soil differs materially in its chemical contents, and the configuration of the plant is greatly modified by the different types. Even in so small a territory as Massachusetts there are characteristic variations in the soil which are of sufficient importance to justify specialization in farming. In general, the finer particles of clay, silts, etc., increase from the seacoast to the western boundaries of the state, and the coarser particles,—sand, etc., predominate near the coast.

The river valleys furnish typical soils adapted to the growth of special crops, the meteorological conditions of these localities also emphasizing the individual character of the crops. The coarse and more friable soils of the coast are light and porous and are used largely for such market garden crops as lettuce, cucumbers, tomatoes, radishes, etc. This soil, characteristic of Belmont, Arlington and other towns about Boston, is especially adapted to head lettuce, which is grown more skillfully and successfully in that region than anywhere else. The texture of such a soil is shown in figure 1. It is characterized by a predominance of the coarser particles and a relatively small amount of the finer materials such as silts and clay. A compact soil is shown in figure 2. Except in some few localities

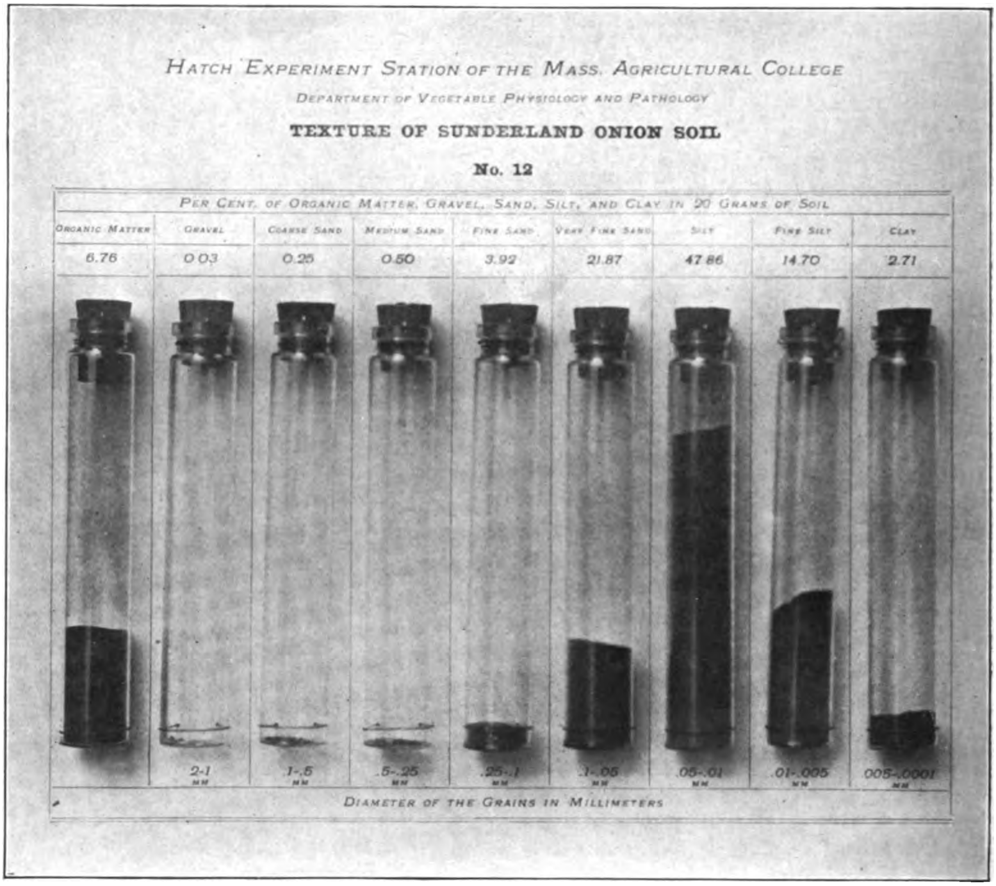


Figure 2

the interior soils are not nearly so well adapted to head lettuce, and for this reason the crop is not grown to any extent outside of Boston. In all its stages head lettuce requires a loose textured soil for perfect development. These soils are manured heavily year after year, and in the greenhouse are never changed; and the large amount of organic matter furnished by the decomposed horse manure renders the soil even better adapted to this particular crop.

The soils in the Connecticut valley differ from other Massachusetts soils in the high percentage of fine sand and silt contained; the fine sand predominating in some, and in others the silt. These soils have long been devoted to the growing of tobacco, onions and cucumbers, and to some extent, melons. While similar in texture, variations occur even in these valley soils which have a marked influence on certain crops. Tobacco in the Connecticut valley, except the tent grown, varies in price from 10c. to 30c. a pound, and the value of the crop is closely related to the texture of the soil, which therefore determines the quality of the crop to a great extent. This is also true to a less degree of onions, of which thousands of bushels are grown in the valley each year. Certain types of soil in the Connecticut valley,—*e.g.*, the warm, sandy textured soils, are unusually well adapted to melon culture, the crop growing more vigorously here than else-

where with less infection from blights, etc.

While asparagus is grown largely in the Cape region, in very dry, sandy soils with little water retaining capacity, it is not especially adapted to these conditions. The finer textured soils of the Connecticut valley are much superior for asparagus, which sometimes yields at the rate of $1,000 per acre in this locality. Besides, in light, sandy soils this crop suffers much more severely from rust than in the finer textured soils.

Roses are grown to quite an extent under glass in Massachusetts, and like tobacco and lettuce, are quite susceptible to the type of soil. This plant requires a very heavy soil, one of the best types being found in the Connecticut valley. A good rose soil should have a basis of about 80 per cent. of fine particles (very fine sand, silts and clay). Some of the best American Beauty soils are found in Pennsylvania, and contain 10 to 12 per cent. of clay and about 40 per cent. of silts. Such soils are not abundant in Massachusetts, although similar types are occasionally found.

There are other crops having a wider range of adaptability which will thrive fairly well on a great variety of soils, but the configuration of the plants will be affected. For instance, the apple can be grown successfully in various parts of Massachusetts, but a too dry or too wet soil should never be selected for it. It grows more luxuriantly in the fine textured soil of the Connecticut valley than elsewhere in our state, but has a tendency to run to wood and foliage; and the quality of the fruit, keeping qualities, etc., are not always so good as of those grown on higher elevations where the soil texture also differs.

The pear tree, on the other hand, will grow anywhere in the state, although in the Connecticut valley the quality of the fruit is inferior and the tree is more susceptible to fireblight and other diseases.

What are known as "drumlins" or clay hills, which are scattered throughout our state, are especially good for pastures, and the growth of hay, timothy, corn, potatoes and other crops; although their natural growth is chestnut. When Massachusetts was producing most of its own agricultural products these hills had the reputation of being the best farming land, and they were used extensively by the Indians and early settlers for farming purposes. As water is always found a few feet below the surface they suffer very little from drought.

The pronounced effects of soil texture, etc., on plant variations may be seen in the growth of our native trees. Of all native species the pine is best adapted to Massachusetts conditions. It will grow in very dry and in very wet soils, and if unmolested would cover the whole state in less than a century. The elm thrives best in certain types of river valley soils, where it produces large, thick, deep-colored leaves and attains a symmetrical growth. Elms also live longer in such a soil.

What is true of the elm is also true of the rock maple, which reaches a high degree of perfection in the Connecticut valley and lives to a great age. Soil or climatic conditions also produce many other variations in the growth of our native trees such as marked modification of branching habit, etc. The distribution of the smaller plants likewise offers many examples of adaptation which cannot be considered here.

Massachusetts has been long enough under cultivation and the crops grown of great enough variety to give one a fair idea of the soils and their general adaptability to crops. But factors such as pathogenic organisms and soil acidity are occasionally found interfering with crop production in certain soils. Massachusetts is naturally a timber state, but notwithstanding the relatively small amount of arable land the market and prices for produce are excellent.

The vast areas of fertile soil in the West when planted to cereals return about $20 per acre, while our market garden soils return from $500 to $2500 per acre. One square rod of greenhouse lettuce gives larger returns than one acre of wheat, and sometimes as much as two acres. A crop of tomatoes fetching $9,000 has been taken from less than three-quarters

of an acre of glass within five miles of Boston, and one-tenth of an acre of greenhouse cucumbers in one case returned $3,500, which is at the rate of $35,000 per acre. Other instances might be given of the enormous returns from intensive agriculture,—in reality only another term for unusually efficient farming. These returns are possible because the greenhouse grower is able largely to manufacture his environment, and to prepare his soil as he wants it; thus adapting his soil to the crop instead of the crop to the soil. When this intensive farming is in wider use the United States will be able to support many more millions of people than at present.

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A GREAT LOCOMOTIVE

THE Baldwin Locomotive Works has recently built a pusher locomotive to help trains over heavy grades on the Erie Road, which is remarkable in size and power. It has a third pair of cylinders and a set of six-coupled driving wheels which are carried by the frame of the tender. The steam is utilized in one pair of high-pressure cylinders and two pairs of low-pressure cylinders, all of which are thirty-six inches in diameter by thirty-two inches stroke. The drawbar pull is eighty tons, and the total weight $477\frac{1}{2}$ tons.

POWERFUL BRAKES

AT A recent experiment on the Pennsylvania Railway, a twelve-car steel train of nearly one thousand tons weight, running sixty miles an hour was stopped within its own length. This was a test of a new Westinghouse brake which may be operated by pneumatic or electric control, and has two shoes for each wheel instead of one.

This new device reduces the time of attaining the maximum brake capacity from eight seconds with the old brake to three and one-half seconds. With the electric control the time is shortened to two and a quarter seconds. A twelve-car steel train running eighty miles an hour could be stopped within two thousand feet.

FIGHTING THE HOUSE FLY

DESCRIPTION OF THE LATEST FORM OF FLY TRAP—SOME EXPERIMENTS SHOWING THAT THE HOUSE-FLY PUPATES IN THE EARTH

BY ERNEST C. LEVY

EXTERMINATION of the house-fly is one of our really important health measures. It is not necessary to go into proof of this today. Every health officer who has studied this question actively in the field, and not just written about it in his office or dabbled a little with it in the laboratory, is convinced that the house-fly is a very active agent in the dissemination of disease. I am going to assume that we all understand this. Moreover, it is surely fair to assume that, in many a case of illness, not itself caused by flies, the delicately poised balance between life and death may well be turned by the annoyance and loss of rest brought about by this pestiferous insect. Still again, there is abundant reason why everyone of us would like to see *Musca domestica*, and all allied species and genera, wiped off the face of the earth.

I think that up to even a year ago, most of us felt that we were engaged in a hopeless kind of fight. We felt that we could of course do a great deal, but that in spite of killing millions of flies and doing our utmost to limit the breeding of this insect, yet their tremendous prolificness—the mere brute force of their numbers—would still get the better of our ingenuity.

This is not true today. The fight against the fly is a winning fight. We now have the necessary knowledge and the necessary machinery. To make these effective, however, we need the same old thing that we need in all public health work—the coöperation of the people. This, in turn, must be preceded by education of the people.

The evolution of our work for the extermination of the fly has been somewhat slow—slow at least for these days. But we have today methods which are perfectly capable of wiping out the fly in any community within a very short time, provided always that the people understand and are ready to help us. More than this, if coöperation of all the people cannot be secured, we know how to eliminate the fly almost completely in any limited section of a city in which the local residents are sufficiently interested to carry on that part of the work which is assigned to them.

In order to fight flies successfully, we must fight them at every stage of their development. This means the keeping apart of flies and all material (especially horse manure) suitable for the depositing of their eggs; the removal, or destruction, of fly-blown material before the eggs have had time to develop into flies or into mature maggots, and the destruction of adult flies by all known means.

It is useless to expect results of a satisfactory nature if any single thing is neglected. Fly-swatting campaigns, for example, kill relatively few flies, even though the actual number killed may go into the millions. Nevertheless, fly-swatting has a decided field of usefulness, in that by this means we get rid of flies which are not reached by other methods, and which will multiply many hundredfold unless destroyed. To claim that fly-swatting is useless because only a few million flies are killed, or that it is worse than useless because these flies should never have been allowed to hatch, is altogether wrong. The life cycle of the fly is so short, from egg to egg, from maggot to maggot, from pupa to pupa, or from fly to fly, that each point precedes every other point as well as follows it. Those who contend that killing adult flies is the wrong way to proceed, because we should have prevented these flies from

ever hatching out, fail to realize that the killing of a few adult flies of a previous generation would have gone really further back than merely preventing these flies from depositing their eggs in a favorable place.

The literal swatting of flies does not, of course, get rid of any very great number of these nuisances, but in all fly-swatting campaigns dead flies are counted regardless of how they were obtained, and hence the term "fly-swatting" is frequently used as essentially synonymous with the killing of adult flies by any method whatever.

For killing large numbers of adult flies no method is so productive of results as the use of traps. By this I do not mean the small fly-traps sold for about 15 cents at hardware stores, and used about the house. Such traps are not found by the flies for a long time, and even then the number which such traps get rid of is relatively small. There are today in use traps of another kind—large affairs about two feet tall and fifteen inches in diameter. These traps are of very stout construction. They are built on the same principle as the smaller traps, but the cone ends in an opening which will admit one's thumb. The flies which once get through this opening and into the trap proper never find their way out again. These traps are, therefore, not only useful on account of the tremendous number of flies which they catch, but, speaking from my personal experience they are encouraging. When one sees flies by the thousand walking and flying about over every fraction of a square inch in such a trap without ever finding the large opening by which they entered, and out of which they could get with equal ease, one cannot fail to feel that it would be a disgrace to admit that an insect with so little sense could outwit man.

These large modern fly traps are not placed indoors, but in the case of residences they are placed in the back yard, and in the case of stores they are placed in the street near the curbstone. The manufacturers of this trap lay great stress on the rôle played by the bait which accompanies each trap. One or two drops of this bait are placed in a saucer of vinegar and put under the trap. The manufacturers claim that the bait so prepared will attract flies from a great distance, even from a kitchen in which a meal is cooking.

My own trap was built by myself at a cost of about 50 cents, and I did not find it necessary to employ any especially manufactured bait. A saucer of vinegar with a liberal sprinkling of sugar around it was in every way successful. Stale beer worked equally well. This trap caught many things besides house-flies. In fact, there was, roughly speaking, about one fly of some other kind to every two or three house-flies. These other flies were green ones and blue ones and gray ones, large and small, but the house-fly was always in evidence, outnumbering all other kinds put together. In addition to flies, my own trap caught regularly large numbers of June bugs, and at one period tremendous numbers of moths about the size of the last joint of one's thumb. Bees and wasps were also caught in considerable numbers. During the summer this one trap caught over three quarters of a million flies, calculated on a basis of 13,000 to a quart.

It can hardly be contended that even one such trap on a city block has no effect on the number of flies prevalent in that block, even though nothing else be done. In my own case, a neighbor living about ten doors from me was hatching flies throughout the summer at a far greater rate than I could catch them. Even under such circumstances, the number of flies on my block must have been lessened not merely by the 750,000 which I actually caught, but by numbers far greater than this, since the flies trapped early in the season would probably have multiplied at least a thousandfold before the end of the season.

After we get complete control over all breeding places, this special kind of trap will probably no longer play a prominent rôle, since it is not effective in dealing with the smaller residual numbers with which we will then have to deal. For this latter purpose smaller traps, tangle-

foot paper, poisons and swatting will meet the situation.

These large fly traps have another distinct field of usefulness, as illustrated by the following case: A mile or so outside of Richmond, Va., there is a very attractive suburban community. From all that I have ever been able to see, there are few, if any, horses kept in this community, and all the lots are apparently free from any large collections of material which would serve as breeding places for flies. But regularly each year this community is literally overrun with flies. It is no exaggeration to state that I have seen at least one tenth of the surface on railings and pillars of porches occupied by flies. Where they come from I have never been able to determine. It is true that I have never made a thorough investigation, but there is no section of Richmond where I have ever seen flies as prevalent as they are in this suburb. Of course, these flies breed somewhere, either within or without the boundaries of this suburb, and an investigation would ultimately determine where. Pending this, however, it would be entirely practicable for this community to reduce the number of flies to a small percentage of their present numbers if each householder would use even one of these traps and look after it properly.

It seems to me that there is room for good work in determining what is the best bait to be used in traps of this kind. It would be desirable to find a bait which would attract flies but not moths, June bugs, wasps, bees, etc., since these insects consume the sugar far more rapidly than do flies, and thus necessitate more frequent rebaiting, besides which there are obvious personal objections to dealing with a trap in which the two insects last mentioned are present.

I shall not discuss at length the very important questions of stable construction and removal of manure. It is useless to expect very good results unless these things are properly looked out for. I am inclined to believe that the statement that 90 per cent. of all house-flies in cities breed in horse manure is far below the mark, and that very small numbers breed in any other material. Even though this be so, we must nevertheless believe that in a community in which there are no horses, or in which all horse manure is so perfectly handled that it never becomes accessible to flies, house-flies would deposit their eggs in other organic matter, if such were available. In fact, I frequently found during last summer large numbers of fly eggs laid on the bare wire of my large fly trap. Whether these were the eggs of the house-fly or of one of the other 57 varieties I am unable to state, but it would appear from this as if the female fly is unable to retain mature eggs beyond a certain point, but must deposit them somewhere.

Stable floors should by all means be of tight construction. I have frequently seen maggots disappearing in cracks less than one eighth of an inch wide between wooden blocks in a stall. Whether or not such maggots pupate, and whether or not they could ever emerge as adult flies, is another question which I have not had time to look into.

Recent experiments conducted by the Richmond Health Department have caused me to hold views quite different from those generally accepted in regard to stable construction and removal of manure. These experiments have been told briefly in a paper published a few months ago.* They convinced me that the house-fly does not normally enter the pupa stage in manure if the adult maggot finds it easy to leave the manure and enter the earth. Since the paper above mentioned was written, additional experiments have been conducted by us. I will relate one of these briefly. Two wooden soap boxes, about two feet long and one and a half feet wide and nine inches deep were used in this experiment. In one of these boxes was placed fresh horse manure. This was supported on wire gauze with a mesh of about one half an inch, the bottom of this box having been first knocked off. This box was placed on top of a second one of exactly the same kind. This lower box was first filled with dry earth. The two boxes thus arranged were

*A. M. Jour. Public Health, Vol. 3, No. 7.

placed near a stable. At the end of 24 hours the manure in the upper box was loaded with eggs of the house-fly. Fine wire gauze was then nailed over the top of the upper box. The manure, meanwhile, had settled down so as to leave a space of about one inch between the upper surface of the manure and the fine wire gauze. Maggots developed promptly, but three days after the beginning of the experiment all the maggots had apparently left the manure box. Examination of the lower box at this time showed it to be swarming with large maggots. We then separated the two boxes and screened the lower one, which, to repeat, contained finely divided earth. We got thousands of flies from the box of earth, but not one from the box of manure, nor did careful examination of this manure show a single maggot or pupa. In other words, every maggot had left the manure and gone into the earth.

Our experiment went even further than this. The wooden bottom of the lower box (the one containing the earth) had in it several small holes and cracks which we had failed to notice. Not only did all the maggots go through the nine inches of manure in order to get to the earth in the lower box, but a very considerable number of them continued on down through the nine inches of earth in the lower box, and then got out of this box through the holes and cracks above mentioned, as was shown by the fact that we found in the earth immediately under this box, and for several feet around it, maggots and pupæ. This experiment surely sustains our point—namely, that the house-fly does not normally pupate in manure but in earth.

COLOR COMPOSITION OF LIGHT

IN A recent paper on the "Physics of Lighting," Dean F. L. Bishop of the University of Pittsburg discussed the various methods of producing the physiological effect of light, stating that the normal eye being equally sensitive to red, blue and green light, that a black body heated 6000° C., gives these light values in equal proportions, producing white light; but such a temperature is not commercially practicable.

The color composition of familiar light sources are presented in the following table.:

	Red	Green	Blue
Light from north sky	32.2	32.2	35.8
Overcast sky	34.6	33.9	31.5
Afternoon sun	37.7	37.3	25.0
Hefner candle	55.0	38.8	6.2
Carbon incandescent lamp	51.3	40.4	8.3
Mercury-vapor lamp	29.0	30.3	40.7
Moore lamp, with carbon dioxide	31.3	31.0	37.7

Science Conspectus

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VOL. IV 1914 No. 3

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

VOL. IV 1914 NO. 3

ELEPHANTS AND THEIR PROGENITORS

THE STORY OF THE EVOLUTION OF THE ELEPHANTS OR PROBOSCIDEA FROM THEIR EARLIEST RECORDED ANCESTOR, THE MŒRIS BEAST

BY RICHARD SWANN LULL

THE elephants seem so essentially foreign to the New World that one is surprised to hear of their former existence as a conspicuous element in the past fauna of North America, and especially of the discovery of at least six specimens of the prehistoric mastodon within the confines of New England, of which one, discovered at Colerain, Massachusetts, was a denizen of what, years later, was to be part of the Commonwealth itself.

The elephants, standing as they do, so utterly aloof from all other mammals, are nevertheless related on the one hand to the conies (*Hyrax*) of Scripture, the feeble folk that make their houses in the rock (Proverbs, xxx, 26), and on the other to the Sirenia or sea cows, exemplified by the manatee of Florida. The resemblance is in neither case apparent, for, in the one instance, disparity of size is remarkable, and in the other, difference of habitat, but the remote ancestors of all were the same and the resultant divergence is largely the result of habits and environment.

The evidence for the evolution of any group of forms is threefold. First, the anatomy of the creature in comparison and contrast to that of other forms; secondly, the ontogeny or individual life history from conception to death, which according to Haeckel gives a brief though somewhat distorted summary of the evolutionary history of the races, and third, the documentary evidence; that of the fossil representatives found in the older and older rocks, which when placed in proper sequence and properly interpreted is final and unassailable proof.

Elephantine anatomy is an abundant source of knowledge; the ontogeny has taught us little, mainly from dearth of material; while the fossil record as far back as it goes is very full and complete.

ANATOMICAL EVIDENCES

The elephants show a curious intermingling of archaic and highly specialized features, the body, aside from its increase of size, changing but little as time goes on, the head undergoing a most remarkable modification. The archaic features are mainly in the feet, the retention of five—the original number—toes, though the nail-like hoofs may be fewer. The bones of the wrist are arranged serially, that is, one above another, in contrast to their alternating position in most mammals, especially those in which the foot is subjected to splitting strains. The limbs are primitive also in

the retention in the forearm and lower leg of two well-developed bones, one of which in each member tends to be reduced when an animal is modified for speed. In its soft anatomy, as well, the elephant shows several ancient characters as compared with the host of its contemporaries; among them being the general form of the brain, although, as we shall see, it is also highly specialized.

The specializations are, first, immense size, which is much greater than that of any terrestrial creature the world has ever seen, only excepting the ancient dinosaurs of the Mesozoic period. A typical and very well-known elephant would be "Jumbo" whose height was eleven feet, with a weight of six and a half tons. In order to carry this immense bulk the limbs have become pillar-like in contrast to the sharply angulated limbs of the horse.

The head shows several lines of marked change, all of which are, however, interdependent upon one another. They are, first of all, an alteration of the form of the skull, which becomes relatively shorter and higher to provide greater leverage for the huge muscles of the neck to meet the increasing weight of trunk and tusks. This is accomplished, not so much by the increase in the actual size of the brain cavity as by the separation of the outer and inner surfaces of the skull bones and the development of air spaces or diploë between them. This form of the bone also extends to the upper jaw to provide space for the huge teeth. In the skull of the newborn elephant this feature is not shown but develops with age just as it has in time—almost the only evidence which ontogeny casts upon the evolution of the skull. The proboscis, perhaps the most distinguishing elephantine feature, is a wonderfully complex muscular organ, the combined nose and upper lip terminating in one (Asiatic) or two (African elephant) finger-like processes, so that the trunk combines the strength sufficient to uproot a tree with the wonderful delicacy whereby minute objects are picked up from the ground.

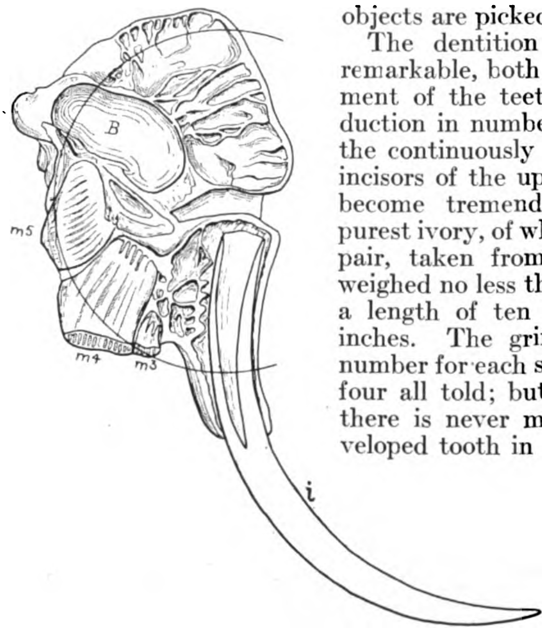


Fig. 1.—Sectioned skull of Indian elephant; after Owen

The dentition of the elephants is remarkable, both for the great enlargement of the teeth and the extreme reduction in number. The tusks represent the continuously growing second pair of incisors of the upper jaw and they have become tremendous structures of the purest ivory, of which the largest recorded pair, taken from an African elephant, weighed no less than 463 pounds and had a length of ten feet, three and a half inches. The grinding teeth are six in number for each side of each jaw, twenty-four all told; but because of their size there is never more than one fully developed tooth in a jaw at any one time, though one partly developed and one partly worn out may be simultaneously in evidence. Each tooth consists of as many as twenty-seven transverse plates of ivory or dentine, overlaid by enamel and separated from one another by the cement which serves to bind the entire tooth together. These three substances differ in hardness, so that the enamel which is the most resistant stands above the other substances in the partly worn tooth as a series of ridges separated by shallow valleys, thus forming a splendid grinding device. The method of tooth replacement from behind forward is also unique, the teeth moving toward the front of the jaw through the arc of a circle as fast as they are worn away, while the full

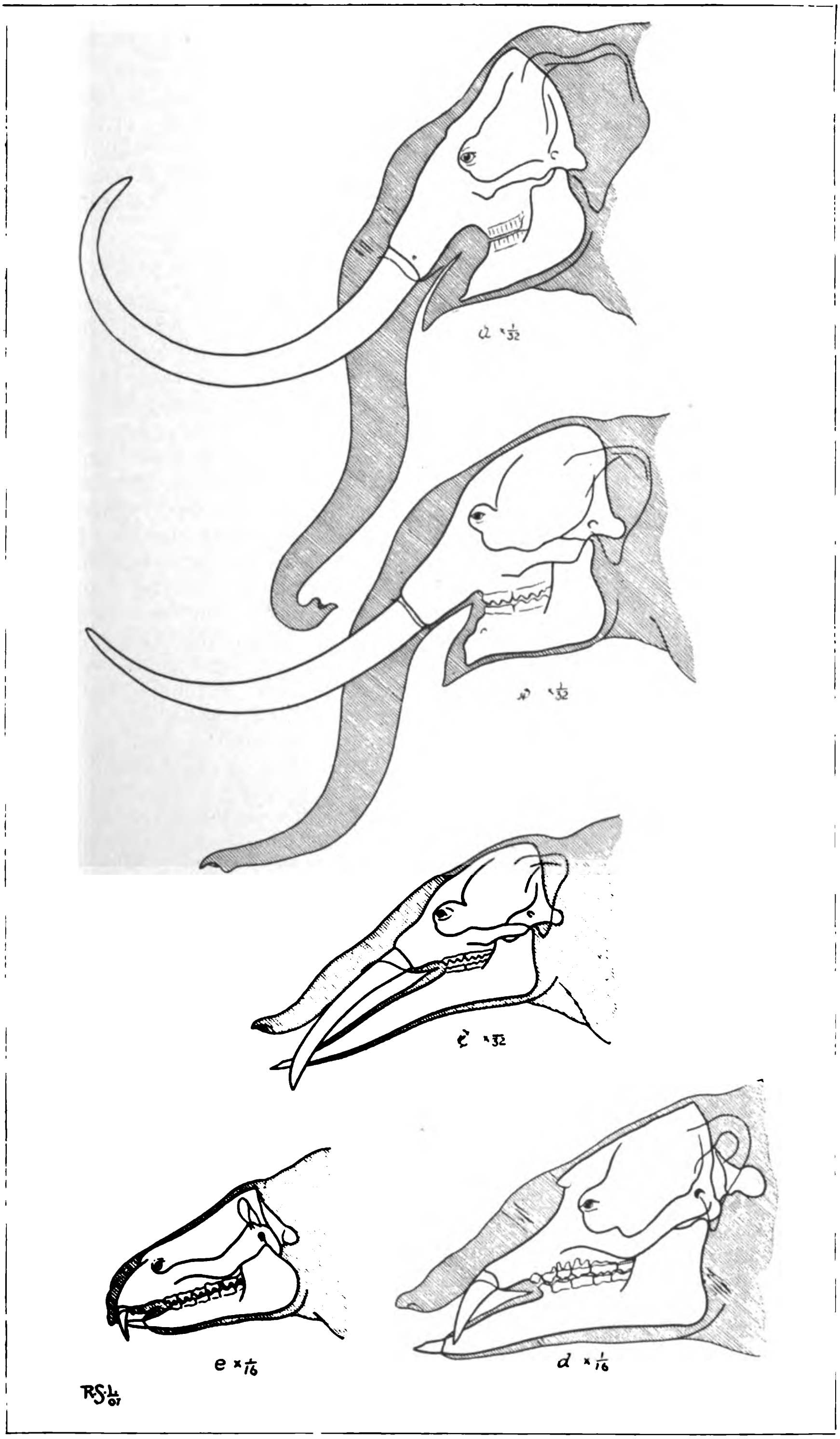


Plate I.—Evolutionary changes of Proboscidia. Based upon restorations modeled by R. S. Lull.
a, Elephas columbi; b, Mammut americanum; c, Tetrabelodon angustidens; d, Palæomastodon; e, Mœritherium.

amount of tooth substance produced is nicely calculated to last the creature's possible lifetime of a century or more.

The brain, characterized as it is by great size, at least twice that of mankind, is also very well convoluted and is the seat of an intelligence second only to that of the higher apes and carnivores.

Doubtless, as in the case of mankind, much of the higher mentality is due to the elephant's ability to lift objects before its eyes for examination. The intelligence of the elephants has, however, been both exaggerated and minimized. Elephants possess a remarkably memory of injuries, real or fancied, of misfortunes, and of the time and place of the ripening of favorite fruits. They also learn to perform complex labors, as the carrying and piling of logs in the teak yards in India, without other directions than the initial order. They are said to be weatherwise and to be able to foretell rain some days in advance. Elephants are obedient and docile, notably those of India, but the males especially are subject to periods of nervous excitement, apparently of a sexual nature, known as "must," when they become very dangerous and sometimes destroy the keepers in their paroxysms of rage. Ultimately all male elephants become surly and intractable. In the wild state such are known as rogues and live apart from their kind until they die. Elephants are rightly accused of timidity and cowardice, though when brought to bay rage may simulate courage, making a charging tusker a formidable foe. In common with most forest and jungle dwellers, elephants, while relatively dull of sight, are keen of scent and hearing, in fact marvelously so, for, as Schillings tells us, they either have an acuteness of some known sense far beyond our comprehension or possibly some other sense unknown to us. The sentinels of the herd stand with uplifted trunk, which emphasizes the value of the sense of smell.

Elephants rarely breed in captivity, almost all of the tamed individuals having been born wild; hence artificial selective breeding, which has given rise to such valuable results in the betterment of domestic animals, is unavailable for the improvement of the race. The slow rate of increase, however, implies some most effective check in the struggle for existence, for aside from man the elephant has no known enemy today, in spite of which fact its total numbers do not increase.

SUMMARY OF EVOLUTIONARY CHANGES

Notable among these are the increase in size, and the change in the form of the skull from the long, low type seen in the earliest known ancestor to the short, high cranium of the living form. The evolution of the tusks is also very remarkable, for at first there were four, two in the upper and two in the lower jaw. Of these the lower ones projected straight forward and were used for digging, while the upper ones curved downward instead of upward as in the later types. As time went on, the lower tusks elongated, together with the union or symphysis of the jaws, until about midway in the evolutionary sequence they reached a mechanical limit of utility. The jaw then rapidly shortened and the lower tusks disappeared except in the males of the persistently primitive American mastodon, which retained until their extinction one or two relatively small and apparently functionless relics of these teeth. In the living elephants the short spout-like projection of the lower jaw is a vestige of its old elongation. The trunk had its first inception doubtless merely as a short prehensile or grasping lip which aided in securing food. With the elongation of the jaw this lip lengthened as well, forming with the nose the continually extending proboscis, which, while it kept pace with the growing jaw, was of necessity limited in its range of usefulness, until with the secondary shortening chin it became the pendant organ the elephants now possess.

The teeth increased the number of the transverse ridges, which at first were relatively few, with no intervening cement, until the complex grinding device was perfected; they also reduced in number and changed their mode of succession from the normal vertical sequence of milk and permanent dentition usual

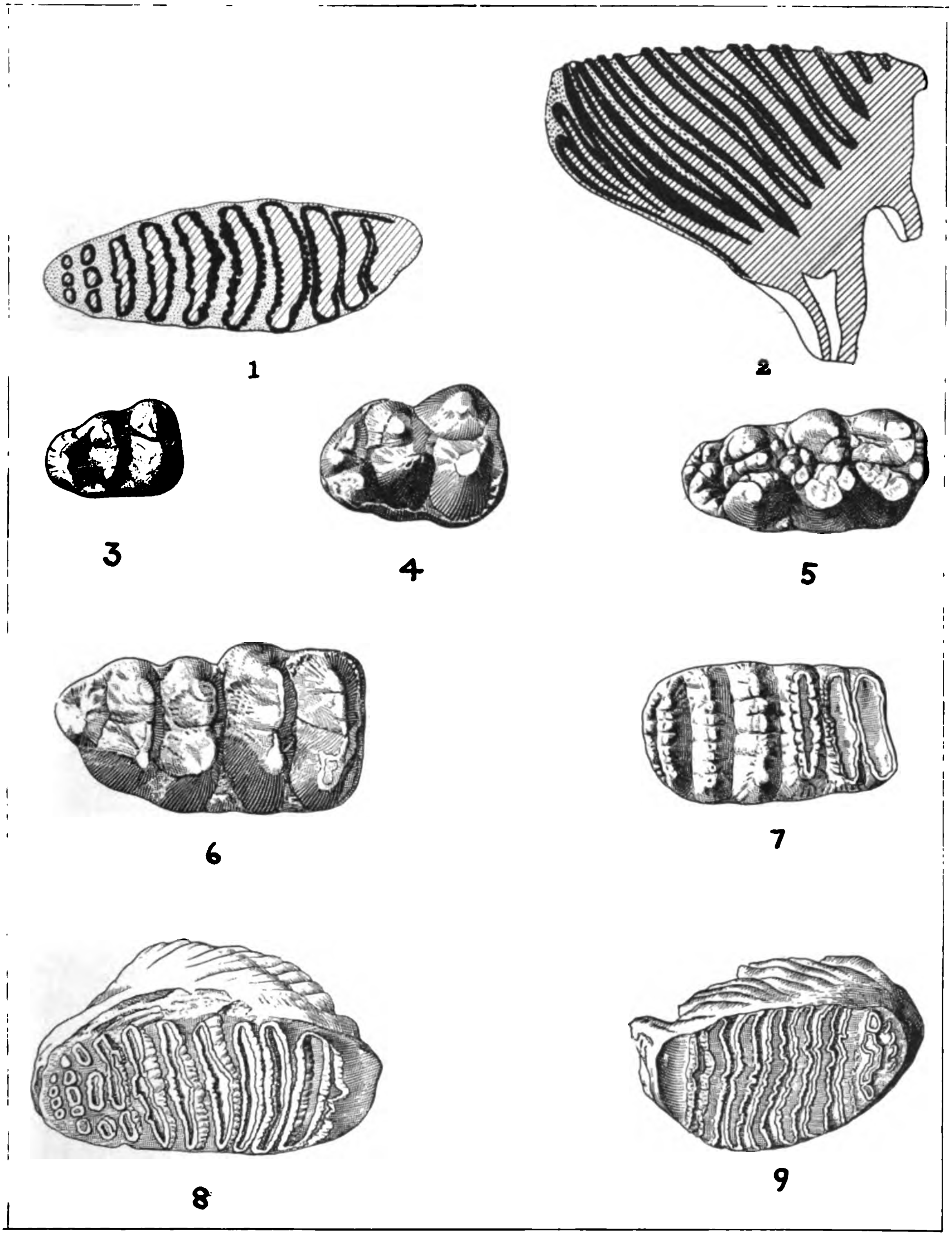


Plate II.—Figs. 1, 2, Crown view and section of a proboscidian molar tooth. Figs. 3-9, Evolutionary changes in teeth of Proboscidia; *3, Mœritherium; 4, Palæomastodon; 5, Tetrabelodon angustidens; Mammut; 7, Stegodon; 8, Elephas imperator; 9, E. columbi*

with mammals to the linear succession of the elephants.

FOSSIL RECORD

The science of palæontology has brought to light a marvelous evolutionary series of more or less complete elephants from their first recorded appearance to the present time. The oldest relics were found not many years since (1901) in the region known as El Fayûm in Egypt, about fifty-seven miles south and west of Cairo near the present Lake Birket-el-Qurûn, itself a brackish relict of the larger, artificially controlled, fresh water Lake Mœris. Along the northern shores of old Lake Mœris there are extensive deposits of Tertiary rocks wherein are entombed more or less abundant relics of a past fauna, conspicuous among which are those of the ancestral elephants. Of these the oldest, in strata of Middle Eocene age, is the Mœris beast, *Mœritherium*, probably a proboscidian but also not far removed from the ancient Sirenian stock. *Mœritherium* is not completely known but evidently stood two and a half to three feet at the shoulder, with simple teeth fitted for the succulent

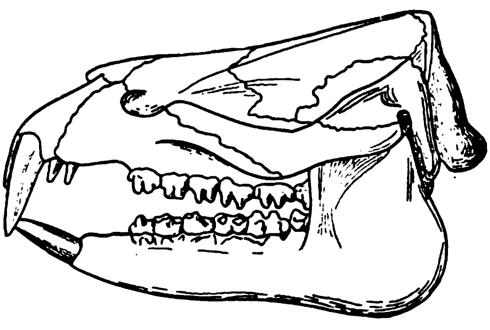


Fig. 2.—*Mœritherium* skull; after Andrews

semiaquatic herbage of that day. The skull is long and low but the hinder part of the cranium is already beginning to develop the air cells or diploë and the nasal bones are commencing to recede, indicative of an incipient trunk. The lower jaw with its procumbent tusks is only slightly elongated, and, while the upper tusks which are the second pair of incisor teeth, are well developed and dagger-like, the other incisor teeth (the first and third) as well as the canine teeth are present.

The Fayûm has also yielded *Palæomastodon*, the successor to *Mœritherium*, in beds of Upper Eocene and Oligocene age. This animal is more elephant-like than

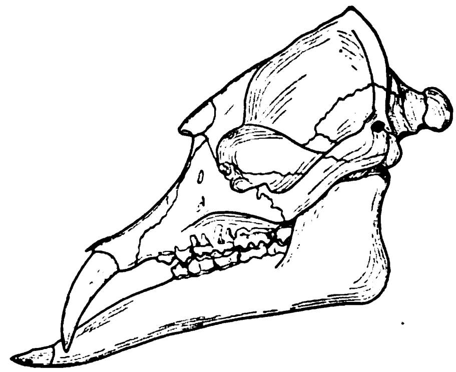


Fig. 3.—Skull of *Palæomastodon;* after Andrews

its predecessor and is larger in size, standing four and a half feet in height. The skull has heightened materially, with a considerable development of air cells in the bones. The small nasals with the narial openings have receded so that they lie just in front of the orbits as in the modern tapir, which would indicate a short extensile proboscis essentially like that of the modern elephant except for size. There is but one pair of tusk-like teeth remaining in the front of each pair of jaws and of these the upper ones, particularly, are large and downward curved, with a band of enamel on their outer face. The lower jaw shows a considerable elongation.

The third recorded stage in the evolutionary series is *Tetrabelodon*, Miocene form and a world-wide wanderer, for this is the proboscidian which escaped from the confines of the Dark Continent, probably by way of a temporary land bridge of which Sicily, Malta and Italy are latter-day relics. *Tetrabelodon* is known in Africa, Europe, Asia and even in North America. It was an animal of considerable size, nearly as large as the living Asiatic elephant, and with a body essentially elephantine in its contour;

the great contrast lay, however, in the immensely elongated lower jaw, which reached the maximum possible from the point of view of an efficient mechanical device. The upper tusks are still down-

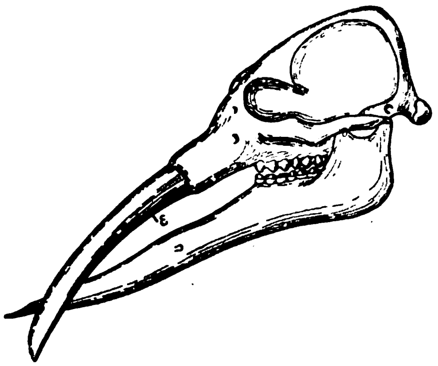


Fig. 4.—Skull of *Tetrabelodon angustidens*

ward curved and continue to possess the enamel band. The proboscis was fully developed but limited in its range of utility by the rigid lower jaw. The teeth are quite complex and have attained such size that but two adult grinders can be contained within the masticating limits of each jaw at any one time.

Tetrabelodon was succeeded by *Dibelodon,* in which, while the upper tusks still retained the enamel, the lower ones had

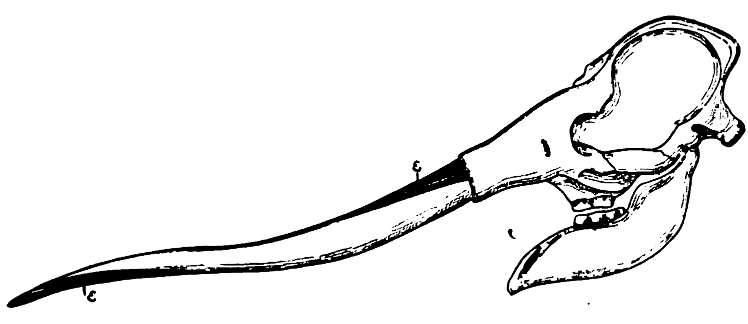


Fig. 5.—Skull of *Dibelodon andium*

disappeared and the symphysis was reduced to a spout-like prolongation, relatively longer, however, than in succeeding types. *Dibelodon* is known from the rocks of Pliocene age in both North and South America, and seems to have been the only proboscidian to cross the newly emerged land bridge of Panama. Why none of its successors, except possibly an isolated imperial mammoth, ever succeeded in reaching South America we do not yet know.

Another Old World derivative of *Tetrabelodon* was the great mastodon (*Mammut*) which also ranged to North America, where it persisted until after the final extinction of the mammoth and may have been a contemporary with pre-Columbian man. In the mastodon, the large upward curved upper tusks had no enamel; as I have said, the lower ones are sometimes present, though one only may persist of the original pair. The teeth are large, low-crowned, with four or five transverse crests, and are adapted to browsing upon succulent vegetation. In stature the animal was not very tall, seldom exceeding ten feet, but it was ponderous of bulk, and this, together with its low-crowned head and coarse, hairy covering must have given it a very archaic aspect.

Another curious proboscidian, evidently an aberrant side line of unknown ancestry, is *Dinotherium,* found in Miocene and Pliocene strata of Europe and Africa. While the body was again elephant-like in every detail, the skull was very low and flat and bore no *upper* tusks at all. The lower jaw, however, was recurved at the symphysis and the sharp inferior tusks pointed downward and slightly backward. The teeth, which had but two crests, were very primitive and had the normal mode of succession, indicating that *Dinotherium* diverged from the main proboscidian stem very early in the evolutionary history of the race.

Certain transitional elephants, known as the Stegodons, had teeth midway between those of the mastodons and true elephants. These forms shortly gave rise

to the final stage of the race, *Elephas* itself. They seem to have had their origin in India, whither their ancestors went and whence they migrated to Africa, back to Europe, to the rest of Asia, and finally to North America, so that their wanderings were well-nigh world-wide.

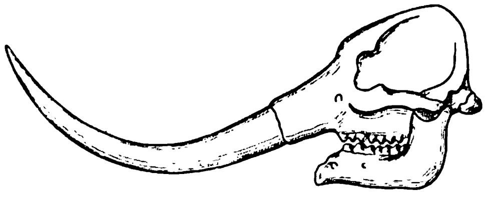


Fig. 6.—Skull of the American mastodon

Of the true elephants three were known in Europe and three in North America, one of which was common to both the Old World and the New. Of the American types the oldest in point of time was *Elephas imperator*, the imperial mammoth, Pliocene and early Pleistocene in time and widespread over what is now the United States and Mexico. This majestic type has never been rivalled, for it stood thirteen and a half feet at the shoulder, with tusks ten feet or more in length and with huge, coarse ridged teeth. The imperial mammoth was succeeded by *Elephas columbi*, whose stature rarely exceeded eleven and a half feet, but whose tusks reached the maximum of length and curvature, those of an old male actually crossing each other at the tip so that their primal function of digging was lost, nor could they have served as very efficient weapons. They have been looked upon as instances of "momentum in evolution," structures which, long past the point of greatest efficiency, became an actual menace to the owner.

The Columbian mammoth merges almost insensibly into the woolly mammoth, *Elephas primigenius*, of the Glacial period, and may have been its actual ancestor, but the evidence for this is not yet clearly demonstrated. The woolly mammoth or "The Mammoth" as it is generally called, was circumpolar in distribution, extending from England across Europe, northern Asia, and North America, where its range overlapped that of *Elephas columbi* along the southern frontier. The mammoth was about the stature of the living Asiatic elephant, from seven to nine feet. It was guarded against extreme cold by a heavy woolly undercoat covered by longer hair. The tusks were of two sorts, short and relatively straight, or long and curved, which was possibly a sex distinction. When one learns that the mammoth tusks (which constitute perhaps one-half the annual output of commercial ivory) thus far secured represent no fewer than forty thousand individuals, he realizes the enormous numbers of these creatures which formerly existed. Entire mammoths are found occasionally in the frozen soil of Siberia, three instances of which are notable. One from the Lena Delta was secured in 1806 and may be seen with part of the hide still adhering to the skeleton in the Zoölogical Museum of the Imperial Academy of Sciences in St. Petersburg. A second from Beresovka was discovered in 1901 and is also mounted in St. Petersburg, the skin in the constrained posture in which the creature died, the skeleton in walking position beside it. The latest find is now being prepared for exhibition at the Muséum

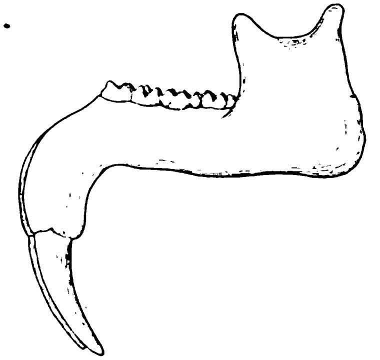


Fig. 7.—Jaw of *Dinotherium;* after Kaup

d'Histoire Naturelle at Paris, and comes from the great Liakoff Island in the New Siberian archipelago. When the exhaustive analysis of this last-found creature shall have been completed, our knowledge of the anatomy of this prehistoric form will be practically as great as of that of the existing elephants.

PREHISTORIC ELEPHANTS AND MAN

Direct evidences of the association of man and the mammoth are plentiful in Europe but, strangely enough, absolutely wanting in North America, although we have every reason to believe that such an association existed in the New World as well as in the Old. In Europe not only have the bones of man and the mammoth been found intermingled in a way that implied strict contemporaneity, but still more striking evidence is shown in the works of prehistoric artists. The fidelity with which the mammoth is drawn indicates that the artist must have seen the animal alive.

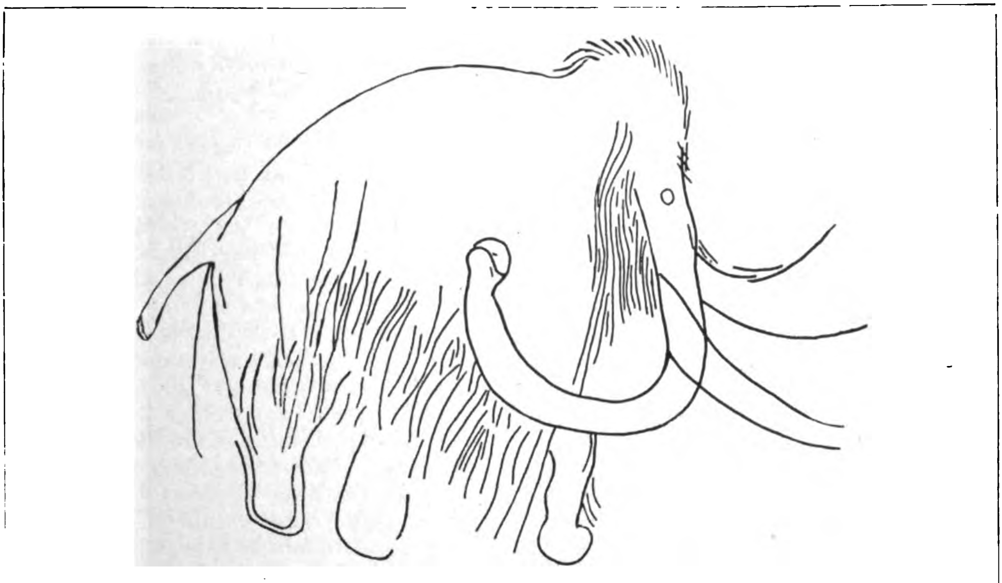


Fig. 8.—Prehistoric engraving of mammoth on wall at Combarelles; after MacCurdy

One of the most notable of these relics is an engraving of a charging mammoth drawn upon a fragment of mammoth tusk found in a cave dwelling at La Madelein in southern France. In the Grotte des Combarelles (Dordogne), France, there are, in addition to some forty drawings of the horse, at least fourteen of the mammoth. These are mural paintings or engravings, the former being executed in a black pigment and some kind of a red ocher, while the latter are scratched or deeply incised, sometimes embellished with a dark coloring matter (oxide of manganese). It is especially interesting to note that the people of that day were sufficiently advanced to have artists of a very high order.

In the caverns of Font-de-Gaume in southern France there are at least eighty pictures, largely those of reindeer, but including two of the mammoth. The actual association of man and the mammoth in America has not been proven. In Afton, Oklahoma, is a sulphur spring from which have been brought to light remains of the mammoth (*Elephas primigenius*) and mastodon (*Mammut americanum*) and numerous other animal remains, such as the bison and prehistoric horses. In the spring were also found numerous implements of flint, mainly arrowheads. This naturally was first interpreted as an instance of actual association of mankind and the elephants, but careful investigation proved that the elephant remains far antedated the human relics, and that the latter were votive offerings cast into the spring by recent Indians as a sacrifice to the spirit occupant, the bones being venerated as those of their ancestors (Holmes). Another instance, not of the

association of the mammoth with mankind, but of the mastodon, is probably authentic. This was in Attica, New York, and is reported by Prof. J. M. Clarke. Four feet below the surface of the ground, in a black muck, he found the bones of the mastodon, and twelve inches below this, in undisturbed clay, pieces of pottery and thirty fragments of charcoal (Wright). The remains of the mastodons and mammoths are very abundant in places, the Oklahoma spring already mentioned producing one hundred mastodon and twenty mammoth teeth, while the famous Big Bone Lick in Kentucky has produced the remains of an equal number of fossil mastodons and elephants.

Indian tradition points but vaguely to the proboscidians, and one can not be sure that they are the creatures referred to, yet it would be strange if such keen observers of nature as the American aborigines should not have some tales of the mammoth and mastodon, if their forefathers had seen them alive. One tradition of the Shawnee Indian seems to allude to the mastodon, especially as its teeth led the earlier observers to suppose that it was a devourer of flesh. Albert Koch, in a small pamphlet on the Missourium (mastodon) discovered by him in Osage County, Missouri, and published in 1843, gives the tradition as follows:

"Ten thousands moons ago, when nothing but gloomy forests covered this land of the sleeping sun—long before the pale man, with thunder and fire at his command, rushed on the wings of the wind to ruin this garden of nature—a race of animals were in being, huge as the frowning precipice, cruel as the bloody panther, swift as the descending eagle, and terrible as the angel of night. The pine crushed beneath their feet and the lakes shrunk when they slaked their thirst; the forceful javelin in vain was hurled, and the barbed arrows fell harmlessly from their sides. Forests were laid waste at a meal and villages inhabited by man were destroyed in a moment. The cry of universal distress reached even to the regions of peace in the West; when the Good Spirit intervened to save the unhappy; his forked lightnings gleamed all around, while the loudest thunder rocked the globe; the bolts of Heaven were hurled on the cruel destroyers alone, and the mountains echoed with the bellowings of death; all were killed except one male, the fiercest of the race, and him even the artillery of the skies assailed in vain; he mounts the bluest summit that shades the resources of the Monongahela, and, roaring aloud, bids defiance to every vengeance; the red lightning that scorched the lofty fir and rived the knotty oak glanced only on this enraged monster, till at length, maddened with fury, he leaps over the waves of the West, and there reigns an uncontrolled monarch in the wilderness, in despite of Omnipotence."

EXPERIMENTS IN ANABIOSIS

PROFESSOR BACHMETIEF, a Russian scientist, has been making experiments with a view to ascertaining whether anabiosis, or suspended animation of the vital functions, can be produced in the higher organisms as well as in the lower forms of life. He found upon examining insects in decreasing temperatures that death would occur at −10 degrees centigrade. Death was at first thought to be due to the freezing of the humors, but it was found that these froze at 5 degrees. At temperatures between 5 and 10 degrees, this strange condition of anabiosis occurs. Animals in this state can be repeatedly revived, even after a considerable time, by a gradual rise in temperature. Experiments were afterwards made on bats and white mice.

Professor Bachmetief was making his experiment with a view of finding a safe cure for tuberculosis, it being known that the microbes producing this disease will die at −6 degrees centigrade. The professor expresses the opinion that it would be advantageous to produce anabiosis in domestic animals that are unproductive in the winter, and to restore them to life when required.

We have also referred in SCIENCE CONSPECTUS to experiments which have been made in producing anabiosis in fish for the purpose of transporting them long distances.

THE INLAND WATERS OF MASSACHUSETTS

HOW THE MASSACHUSETTS DEPARTMENT OF FISHERIES AND GAME IS STOCKING INLAND WATERS WITH THE FISH BEST ADAPTED TO THE ENVIRONMENT

BY DAVID L. BELDING

THE supremacy of her salt water fisheries, as typified by the historic codfish, in the past has overshadowed the inland fishery resources of Massachusetts; but we must not forget that our Commonwealth possesses many beautiful lakes, ponds, and streams, capable of producing an abundance of food and game fish. At the present time few of the 100,000 acres of inland waters are producing anywhere near their maximum or even normal possibilities. It is, therefore, important, both in the interests of sport and as a source of food supply, that these latent assets should be developed for the benefit of the public.

In colonial days, when a relatively small population was scattered along the sea coast, leaving the inland waters in their primitive uncontaminated condition, the abundance of salt and fresh water fish was far in excess of the needs of the colonists, thus giving rise to the fallacy, which has been zealously handed down to the present generation, that "Nature would always provide an abundant supply of fish." Even in this era of conservation this mistaken idea is still deeply rooted among the inhabitants of our shore towns, and it can only be eliminated by the complete exhaustion of the natural supply or by the education of the general public.

With the advancement of civilization, great changes have taken place in our waterways. Many times the balance of nature has been overthrown and a new equilibrium established. With the increase in population, the coastal streams were first invaded; cities were established on the larger rivers and various manufacturing industries were likewise scattered along the smaller streams. In order to supply water power, numerous dams were constructed, in most instances unprovided with suitable fishways, thus preventing the passage of such fish as the salmon, shad, striped bass, alewife, smelt and white perch up the coastal streams to their spawning grounds, and in this way not only depleting the supply of these fish, but indirectly affecting the commercial sea fisheries by destroying a food supply which attracted the larger predacious fish to our shores. Manufacturing wastes and sewage, particularly in the central part of the Commonwealth, have totally ruined many streams, and have seriously depleted the supply of fish in others, by rendering the water unfit for fish life. Numerous legislative measures have been enacted in the past, but the decline has steadily continued as these laws were either inadequate or, as more often the case, were not enforced. Likewise, overfishing has depleted local supplies and has accelerated the general decline which is so marked in the Merrimac, Charles, Taunton and Connecticut rivers.

For the purpose of checking this depletion by stocking public waters with fry and fingerling fish, the Massachusetts Department of Fisheries and Game was established in 1866. In the early days, salmon and shad hatcheries were located on the principal rivers as long as any native fish remained; but during the last twenty years brook trout have formed the main output of the state hatcheries. In the past the fish, which have been reared in considerable numbers at the hatcheries, have been indiscriminately dumped into various ponds and streams. In some cases this hit-or-miss stocking has been successful; in others it has been a complete failure, resulting in financial loss, since the environment was not suited

to the life of the fish. The method of stocking which has been used up to the present time in Massachusetts is of little value; results have been inconsistent; streams and ponds have been stocked with the wrong species of fish; and considerable money has been expended without entirely satisfactory results.

It was evident, several years ago, that such a prodigal method should be abolished, and that methods of stocking upon a definite economic basis should be devised in order to obtain the best results for the money expended. Such results can only be obtained by intelligent stocking, whereby fish are put into waters suitable for their best development. It can be conservatively stated that, with proper scientific methods, the production of the inland waters of Massachusetts can be increased at least tenfold over the present output. The benefits derived from the proper development of the inland waters are (1) increased facilities for sport and recreation; (2) more business from vacationists; (3) a larger food supply; and (4) a greater number of cottages and pleasure resorts upon our lakes.

As the first step toward formulating a systematic basis for future stocking, a survey of the inland waters was begun in 1911. The first part, the lakes and ponds, has been finished, while the second, the streams, is at present incomplete. The preliminary step in this work was to ascertain the present condition of the fresh water ponds. Massachusetts has within her borders approximately 875 ponds over twenty acres in area, some of which are used for water supplies by the various towns and cities, others which are artificial, but the majority of which are natural, public ponds, capable of development.

The object of the work was (1) to increase ultimately the supply of food fish and game fish in the public waters; (2) to study the food, growth, spawning, and habits of the different species of fish inhabiting these waters; (3) to determine the species of fish best adapted to certain classes of water; and (4) to make a biological survey of the ponds for the purpose of obtaining the species and quantity of fish, the natural conditions influencing the life of these fish, and to establish permanent records for future stocking.

The general work consisted of two parts: (1) an extensive biological survey of the ponds in regard to their general conditions, to form a guide for future stocking, thus classifying the ponds into certain groups according to the similarity of the natural conditions; (2) an intensive study of various type ponds, representing the groups above mentioned, as regards the effects of the natural conditions upon fish life. In these ponds, records of the temperatures, amount of food (plankton), and the general changes which concern the problem of fish life were followed throughout the year. The work on the type ponds will serve as a basis for interpreting the conditions in the other ponds which, as a rule, fall into five classes. The types under observation present large and small ponds, both deep and shallow, in which the conditions as regards the species, growth and abundance of fish are quite different. The scattered distribution of the water systems allowed but a short time in the general survey for the examination of the individual pond. In every instance the following information concerning the physical characteristics was obtained in order to insure the proper classification of each type:

Name.—The name of a pond is a variable factor. Usually a pond has several names, according to the various maps upon which it is recorded, and often these listed names are unknown in the immediate vicinity where local titles are in vogue. To facilitate the identification of any body of water for public information or for stocking, the primary essential is the recording of all the names by which it is known.

Names, themselves, are interesting as illustrating popular origin. For instance, on Cape Cod, near the ocean, are many Herring Ponds, the name arising from the fact that the alewife or branch herring enters from the ocean through a tributary stream each spring to deposit its spawn. Frequently ponds are named

from their size, shape or general characteristic, *i.e.*, Long, Great, Shallow, Marsh, Muddy, Sandy, Grassy, and Six-Mile. Still other ponds are named after birds, as Swan, Duck, etc., or after the prevailing vegetation as Lily or Cranberry. From the clearness of the water we find the names of Clear and Crystal, too frequently a misnomer at this present time. Among the artificial ponds, the name Mill Pond often occurs, while others have possessive names from the owners or locality. Another class, by far the most interesting, still retains the old Indian names, such as Catacoonaug, Massapoag, Unkechewhalon, Charggoggagoggmanchauggagoggchaubunagungamaugg, etc.

Location.—The situation of the pond as to ease or difficulty of access from railroad stations or nearest village as well as the hotel and boating facilities were recorded for use in future shipment of fry and as a source of information to fishermen.

Area.—No actual survey of the area of the ponds was made, the size being measured from maps or taken from old records.

Depth and Bottom.—Soundings were so made that contour lines, giving the depths, could be charted on diagrams of the ponds, and from these measurements the average and maximum depths were ascertained. The sounding lead was equipped to take samples of the bottom soil, but, unfortunately, on hard or mossy bottom no soil could be gathered by this method, and the nature of the bottom could only be determined in shallow water or from the character of the shores.

Water.—The color of the water was listed as either clear, green or brown. The turbidity was expressed in feet, the number representing the distance below the surface at which a white four-inch circular disc would disappear from view. By means of the maximum and minimum thermometer, the temperature at the bottom was taken in various parts of the pond to determine the presence of springs. In the deepest part, a series of readings were taken at intervals from 2½ to 5 feet to determine the thermocline, or point where the temperature drops rapidly. Deep ponds have three layers of water—a surface layer in which the temperature to a depth of 15 to 20 feet remains approximately the same as at the surface; a middle layer or thermocline in which there is a rapid fall; and a bottom layer of uniformly low temperature. The extent and nature of these three layers, which vary in different ponds and at different seasons of the year, are of importance as regards fish life, from the standpoint of food and oxygen.

Shores.—The shores around the pond were classified as woodland, the kind of trees usually being noted, fields cultivated and uncultivated, such as pasture or meadow, and marsh land. The height and slope of the shores and character of the beach were likewise noted. Cottages, hotels, gunning stands, icehouses, etc., were recorded as indicating the popularity of the pond as a pleasure resort.

Inlets and Outlets.—The inlets and outlets with the volume of water, temperature, amount of sediment and pollution, such as manufacturing waste or sewage, were described. The presence of a dam at the outlet indicated that the pond had either been raised above its original area or that it was wholly artificial. In certain instances it was practically impossible to definitely determine whether a pond thus raised was originally a state pond, ten acres in size, open to the public.

Fish.—Information concerning the different species of fish was obtained from fishermen and people living in the immediate vicinity who were acquainted with the pond. In the rapid survey, it was manifestly impossible to obtain this information in any other way, and for this reason the question of the quality of the fishing and the present production of any pond was only determined in a general way, since the term "good fishing" is but relative, varying with the locality.

Fish Food.—A pond, as defined by the dictionary, is a body of fresh water usually less extensive than a lake. The word "pond" should, however, have a broader meaning. It includes all the organic life within its boundaries, which makes it a complex whole, a perfect unit of animal

and vegetable life. A pond can be likened as it were, to a large organic molecule composed of many atoms, the different species which compose it. But this huge molecule is never stable. Changing conditions are constantly arising in the struggle for existence between the numerous species which inhabit its waters. Therefore, whatever affects any species, no matter how small, changes the interrelations of the whole, and particularly affects the food supply of the fish. The large fish prey upon the small, and the small in turn feed upon the minute floating animal and plant forms in the water. For this reason, the amount of fish that a pond can support depends directly upon the amount of small organisms in the water, and a study of the fish food necessitates a study of the complex life in the whole pond. For this reason, observations upon the animal and plant life, especially the aquatic vegetation which furnishes the brood grounds for the microscopic fish food, are valuable.

The study of fish food was undertaken in two ways: (1) the examination of the stomach contents of various species, both of the small and large fish, under various conditions and at different seasons; (2) the determination of the nature and amount of the floating organisms, plankton, in the different ponds by means of the plankton net of silk bolting cloth. The work was placed on a rough quantitative basis by making careful vertical hauls from the bottom to the surface and by estimating the amount of water thus filtered. The contents were washed into a copper cup at the end of the net, and then transferred to preserving bottles. By means of the centrifuge and Rafter cell method of counting, an approximate idea of the food value in the different ponds of the Commonwealth, as interpreted by the more intensive work on the type ponds, could be obtained.

With a thorough knowledge of the natural conditions in all the ponds and streams in the Commonwealth, the Department of Fisheries and Game, in the future, will be in a position to properly stock the inland waters to the best advantage, and bring them to the state of maximum productivity. On this basis the work can be carried out with the greatest efficiency and economy to the benefit of every citizen of the Commonwealth.

SIMPLE CONVERSION RULES

To change centigrade to Fahrenheit: Multiply the number of degrees centigrade by 2; substract 10 per cent, and add 32.

For example, to reduce 100 degrees centigrade to the Fahrenheit scale, multiply the 100 by 2, making 200; subtract 10 per cent, leaving 180, and add 32, making 212.

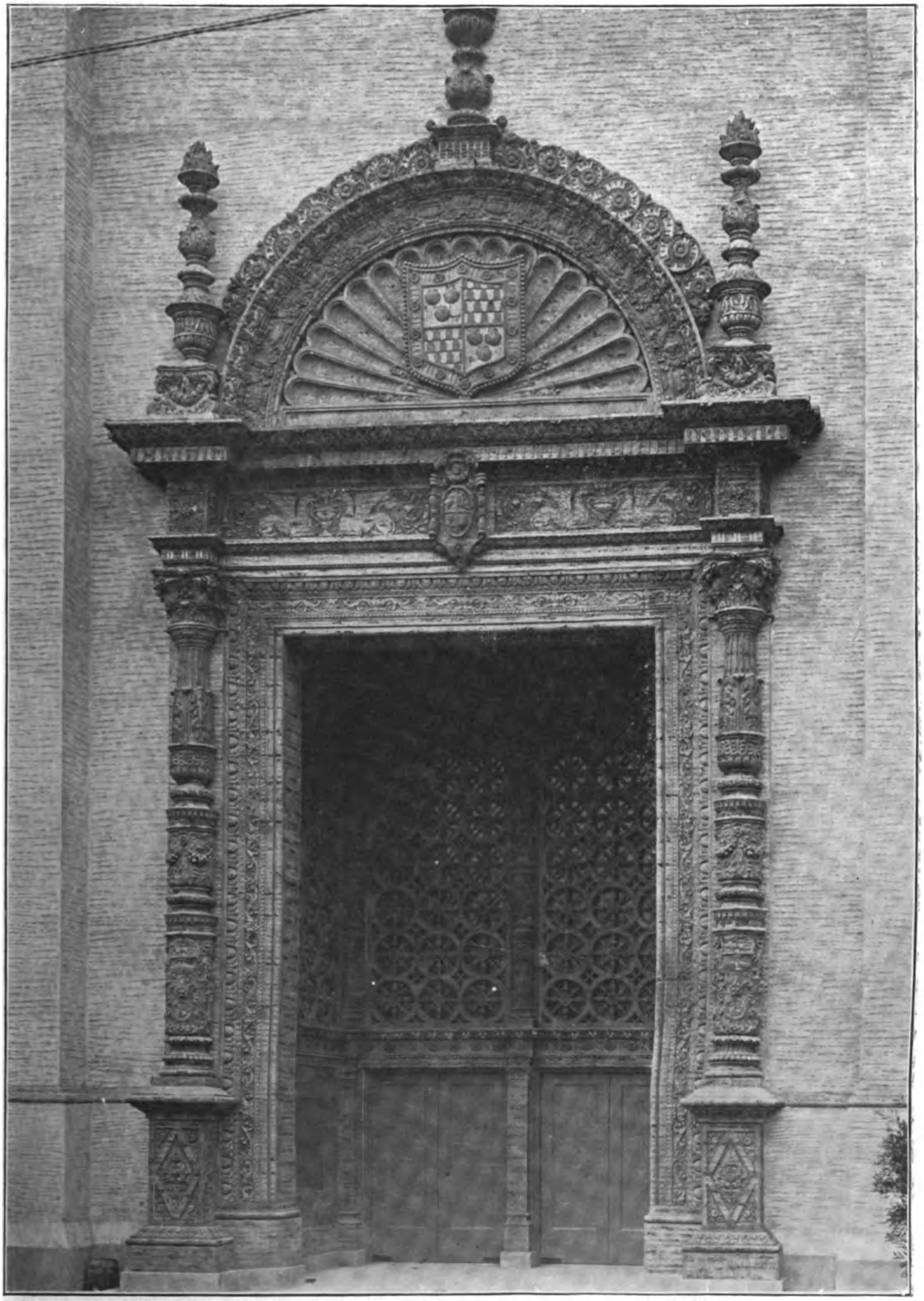
To reduce meters to feet: Multiply the number of meters by 3, add to this number 1/100 of itself, and to this add ¼ of the original number.

For instance, to reduce 100 meters to feet, multiply 100 by 3, making 300; add 1/100 of this number, which is 3, and to this add ¼ of 100, 25, making 328 feet.

A BEAUTIFUL DOORWAY

On the opposite page is presented a picture of a doorway of the palace of Varied Industries at the Panama-Pacific International Exposition. The inspiration of this work was the portal of the Santa Cruz Hospice at Toledo, Spain, a structure which furnishes one of the truest examples of the Spanish Renaissance. It was originally without color, while the reproduction is tinted with blues, reds and browns of the exposition color scheme in the decorative detail. The doorway is mysteriously fascinating in its power to arrest the attention of the visitor.

The General Board of the Navy has calculated that the largest ship that could be built for transit through the Panama Canal would cost $20,000,000 and would be of these dimensions: Length 750 feet, beam 100 feet, draught 28 feet 6 inches, displacement 38,000 tons, speed 23 knots. The largest battleship in our navy at present is 544 feet long, with a tonnage of 26,000.



Doorway in the Palace of Varied Industries, Panama-Pacific Exposition

THE FUNCTION OF ENZYMES

PRODUCTS OF LIVING CELLS THAT AFFECT THE CHEMICAL OPERATIONS OF LIVING MATTER BUT DO NOT BECOME A PART OF THE FINAL REACTION

BY SAMUEL C. PRESCOTT

THE study of the chemical or physiological activity of cells, whether of microbes or of men, is at once one of the most interesting and one of the most difficult problems of the biologist, for it seeks to disclose the secrets of life processes. How does a disease germ produce its poison, or a yeast cell bring about its characteristic fermentation? How do we carry on those transformations of food material by which beefsteak and bread and butter at once become available sources of energy and matter for our living machine? How does a potato manufacture starch in its leaves, transfer it to the growing tubers and there store it up for future use?

In each case by means of enzymes, which we may define as the tools of cells and the reagents by which the chemical reactions of cells of all kinds are effected.

The term "ferments" was first used early in the nineteenth century by Schwann and Berzelius. Afterwards the word was used somewhat indiscriminately, meaning either a micro-organism of fermentation or a chemical substance which in some way was related to living cells. To distinguish between these, the physiologist Kühne suggested the term "enzyme" to designate the digestive ferments such as pepsin, trypsin, and ptyalin. The word has now been universally accepted as the name of a group of chemical bodies, products of living cells, which have the peculiar property of effecting the chemical operations of living matter but which do not enter into the final products of these reactions.

Chemistry cannot produce enzymes, for they are found only as the products of protoplasm of living cells, and it makes no difference whether we are dealing with the ultra-microscopic bacterium or the giant redwood or the whale, the chemical activities are due to enzymes. Furthermore, the same kind of enzyme may be produced by organisms of widely different character, as for example, the trypsin of certain bacteria, of the carnivorous plants like the Venus Fly Trap, and of the human intestinal tract.

Since the variety of chemical processes carried out by living cells is large in number, it follows that the number of enzymes is legion. Even the number produced by a minute bacterial cell hardly visible with a high power of the microscope may be several, while with organisms of highly specialized form and physiological division of labor the number is greatly increased. In man, at least fourteen are known to be developed in the alimentary canal, and to take part in the process of digestion, while, if we added all the other chemical changes which may be elaborated in the body as a whole, our catalogue would be greatly increased. Moreover, we may assume that there are many enzymes which are still unknown, for the enzymes may be intra-cellular, that is, acting only within the cell as well as extra-cellular, or extruded outside the cell and so possibly capable of detection. The positive knowledge of the action of intra-cellular enzymes is still very meagre, although when Büchner discovered zymase and a method for its preparation in 1897, the first great step forward in their study was made.

What an enzyme really is, cannot be exactly stated. An enzyme is known only by its reactions. "By their works ye shall know them," is essentially true in the ferment world. We cannot even tell their composition or to what class of chemical substances they belong for they

have never been obtained in pure condition. It is generally assumed, however, without proof, that enzymes are protein-like in character. In spite of this indefiniteness and the elusive character of these bodies, certain general properties regarding them have become known and on these points all enzymes behave in like manner, although differing distinctly from other chemical substances.

We may thus regard enzymes as forming a special and peculiar group of chemical compounds, differing in certain ways from other substances, and especially in their relation to the law of mass action as shown by the great disproportion between the amount of the active substance and the amount of material changed. A good example of this is rennet which it has been stated can coagulate from 500,000 to 800,000 times its weight of casein, without being used up. All enzymes possess the same characteristic but not necessarily in the same degree. The activity is largely dependent upon the physical and chemical conditions of the environment. Thus very slight changes in the reaction of the medium on which an enzyme is acting may control very largely its power, or make the difference between high efficiency and practical inactivity. Some enzymes require neutral solutions for action, others are most vigorous in slightly acid or slightly alkaline media.

Similarly, temperature may play a very important part in the control of enzyme reactions. In this respect, these substances behave closely like living cells and like certain kinds of proteins. Each enzyme has a maximum, a minimum and an optimum temperature of activity, just as microbes have, and like these, if heated above the maximum, will be rendered inactive and finally destroyed. This thermal death point, as it may be called, is very near the coagulating point of albumin and not far from the death point of most vegetative bacteria. Another similarity to the proteins lies in the fact that both enzymes and albumins are precipitated by concentrated salt solutions such as ammonium sulphate, by alcohol and by salts of heavy metals. Furthermore, they may be more or less completely mechanically precipitated with flocculent or bulky precipitates, as by use of phosphoric acid and lime water. Certain poisons may also inactivate enzymes. Substances which kill living cells, like formaldehyde, hydrocyanic acid or mercuric chloride will in general "kill" enzymes providing the solutions used are strong enough and sufficient time is allowed for the destructive action. The enzyme has a somewhat greater resistance than has the living cell, but the difference is one of degree rather than of kind. In fact so closely do enzymes correspond to micro-organisms in behavior toward physical agencies, poisons, etc., that we use the same terminology in discussing them and speak of the "poisoning" or "killing" of the enzyme. Other substances, such as toluene, chloroform, and a few others, permit enzyme reaction but restrain the activity of living cells, this giving a differentiation of great value in studying them.

Enzymes also have many properties in common with the *toxins*, and, so far as body reactions go, seem to belong to the same class of organic compounds. When a toxin is injected in small amount into the body, certain chemical changes are set up, and there is soon formed a so-called antitoxin which neutralizes or inactivates the toxin. Similarly, the action of enzymes upon the tissues of the living body is effected by the secretion of anti-enzymes, and the injection of foreign proteins into the body may be followed by the manufacture of a "precipitin" which will precipitate that particular protein and no other. This specific action is characteristic of enzymes and toxins as well as of proteins. In view of the fact that enzymes and toxins are, like proteins, the products of living cells, it may not be strange that this similarity is found. However, we are not able to say that enzymes are protein in character but rather that they are found in association with proteins. The purest enzymes yet prepared do not give protein reactions. Moreover, mineral salts seem essential for their action.

We may explain the mechanism of fermentation and putrefaction changes on the basis of the enzymes produced by the inciting organisms, for in recent years it has been shown that the enzymes, carefully prepared and fed from living cells, will carry on the same changes with almost mathematical precision. In yeast, for example, Büchner found within the cells an enzyme which could only be extracted by grinding with fine sand and subjecting to enormous pressure, but which, when thus obtained, produced alcohol and carbon dioxide from sugar in exact accordance to the chemical equation which had long been used to represent the fermentation. Thus it was shown that intracellular enzymes exist, and we now believe that many processes taking place in living cells—perhaps all the processes—are the results of enzym activity.

Since the chemical nature of enzymes is so largely unknown, we can classify them only by their action on various compounds. It is possible, however, to group them into the four classes of *hydrolyzing*, or causing the addition of water to certain substances. Most enzymes acting on carbohydrates are of this class. So also are those that affect fats, and the majority of those producing known proteolytic changes. These are best represented in the processes of digestion. A second group are the *Zymase*, or those producing the splitting of bodies into simpler cleavage products without any hydration. The alcoholic fermentation is the best known of this class.

The remaining two classes are the *oxidizing* and *reducing* enzymes, producing the types of change implied. Of the former, the production of vinegar is a familiar example, alcohol being oxidized to acetic acid by an *oxidase* produced by the acetic bacteria. Such familiar changes as the darkening of freshly cut surfaces of fruits (apples) or the quick change of color when mushrooms and toadstools are broken, also belong to this category. The reduction processes are of enormous variety in nature, both in plant and animal life. While typically distinguished by the reduction of hydrogen peroxide to water and oxygen, these Katalases, as they are called, may also reduce sulphates, nitrates and various coloring matters as well as other compounds. Upon the activity of enzymes may depend all the complex series of changes, oxidations, reductions, synthetic and analytic changes which characterize the processes of growth and decay, renovation and destruction in the cell and in tissues. The phenomenon on intra-cellular fermentation seems to be closely linked with enzymic activity, and the building up and breaking down of protoplasm itself is intimately connected with intra-cellular changes and energy liberation.

There is reason to believe that some enzym actions are like organic chemical reactions, reversible. Thus, maltase will split maltose into two moleculars of dextrose under the ordinary conditions of action. If, however, we add maltase to concentrated dextrose solutions a small amount of maltose (or isomaltose, a similar sugar) will be formed, the reaction proceeding until a certain equilibrium is established. This has not been demonstrated for all enzymes, and some eminent authorities divide enzymes into two classes, only one of which is catalytic and capable of synthesizing as well as splitting substances, while in the other no trace of synthesis has been observed.

On the subject of the origin of enzymes and the causes stimulating their activity, many interesting observations have been made. Some enzymes are produced by cells in such form as to require no further aid to render them active. Others require the presence of a specific substance known as an activator. The pepsin of the stomach is produced by the cells of the gastric glands as a zymogen called pepsinogen, which, under the influence of the hydrochloric acid produced at the time the stomach is functioning, becomes changed to pepsin. We do not know how the enzyme and the acid are associated but we know that the latter is necessary for the production of pepsin and also for its action. Bayliss has described another instance in which the activator itself, enterokinase, acts as an enzyme upon the

zymogen, trypsinogen, thus producing trysin, but without entering into the actual formation of the finished enzyme—trypsin. If this view is correct, we have, in effect, one enzyme bringing a second into existence. In other instances, activation is effected by metals, as in the laccase, the oxidizing enzyme of the lac tree of Asia, which requires manganese; or by salts, such as phosphates, as in certain alcoholic fermentations.

In spite of the apparent lack of exact knowledge of the composition of enzymes and of all their activities, we find in this group of substances agents which are of direct and certain application to industrial processes. Breadmaking, brewing, cheese-making, certain phases of tanning, as well as the preparation of lacquers and castor oil, are a few of these applications.

Here is a field of great promise and infinite interest, sure to yield results if investigated patiently and consistently by the scientist who combines a deep knowledge of organic chemistry with an intimate acquaintance with cell behavior and activity, and this field of bio-chemistry is sure to find greater favor in the immediate future.

CASEIN PRODUCED ELECTRICALLY

Consul Hunt, stationed at St. Étienne, France, reports that casein, the principal albuminoid matter of milk, is now obtained by electrolysis. The milk is heated to 80 degrees centigrade in a large vat, in which is placed a porous vessel containing a 5 per cent solution of caustic soda; an iron cathode is placed in the soda, and carbon rod serves as an anode in the milk. Upon sending through an electric current, the phosphoric acid in the milk is set free and casein is precipitated. This is much cheaper than the old method of precipitating casein by the use of acids or rennet. Vegetable casein is now being produced from the soya bean, and it is said that this material can be put to the same purposes as animal casein. Casein is now largely used as a substitute for ivory, tortoise shell, celluloid, etc.

THE DURABLE FLEA

It is said that the flea, no matter what family name he may bear, is the most durable insect extant. The commoner kinds will recover after being soaked in absolute alcohol until they are completely paralyzed. In some experiments it was found that it takes 100 per cent. phenol more than one minute to kill one of these insects. Water has no apparent detrimental effect, neither has glycerine; and alcohol is inefficient. Formalin, phenol, mercuric chloride and trekesol in the strength used as disinfectants are of little value, and powdered sulphur none. Kerosene and miscible oil were found to be efficient. Bisulphide of carbon, hydrocyanic acid gas and sulphur dioxide were found to be highly efficient in the strength employed for flea destruction. It is, however, a fact that soap and water will put an end to any flea. If dropped in a tincture of green soap, he will live but about two minutes.

FUEL OIL FOR THE NAVY

It is interesting to note that the consumption of fuel oil in the navy is increasing very rapidly, and although but a portion of the fleet is equipped to burn this fuel, about 30,000,000 gallons are used per year. It is estimated that the time will soon come when the fleet will require 125,000,000, and a special board is investigating available oil lands with reference to future supply for the navy. Fuel oil stations will be established at convenient ports.

SOCIETY OF ARTS REPRESENTED

Prof. William T. Sedgwick, head of the Department of Biology and Public Health at the Massachusetts Institnte of Technology, has sailed for Europe, and will represent the Society of Arts at the thirtieth anniversary of the Circolo Matematico of Palmero. The occasion is to be an important one at the great Sicilian University in that city, and it is proposed to celebrate by presenting a gold medal to the founder of the Circolo, Dr. Giovanni B. Guccia.

ADVANCES IN THE STUDY OF STORMS

RECENT EXPLORATION OF THE UPPER AIR THAT HAS SHOWN THE DUAL CHARACTER OF THE ATMOSPHERE AND OPENED A DOOR TO IMPORTANT DISCOVERIES

BY ALEXANDER G. McADIE

AMERICA has contributed its full quota of distinguished names to the science of Aërology, the new name for the older Meteorology; Ferrel, Maury, Espy, Redfield, Lapham and others, not omitting Thomas Jefferson and Benjamin Franklin. The late Lawrence Rotch, with his friend and fellow investigator, the late Teisserenc de Bort, may rightly be given credit for having inaugurated that campaign of upper air exploration which has resulted in the prime discovery of the dual character of the atmosphere, *i. e.*, the troposphere and stratosphere; and the further discoveries of variation in height of the bottom of the isothermal layer with season and latitude.

Numerous records of soundings have been published by the International Commission for Scientific Aërostation. We give one of the latest records made at the observatory at Uccle, Belgium, June 9, 1911, during pleasant weather. A height of 31,780 d. meters (32,430 meters) was reached. The lowest temperature was given by one thermometer (Hergesell) as 212° A. (−61° C.) at 13,040 meters, while the balloon was rising, or 213° A. by the other thermometer (Kleinschmidt) at 12,600 meters, while the balloon was descending.

The skeleton table on this page may be interesting.

Note that the pressure is given in kilobars. We shall return to this later; for the present it is enough to say that the megabar or *absolute atmosphere* is the pressure represented by 1000 kilobars or the force of 1,000,000 dynes. Note also that the temperature is given on the Absolute scale; and that the general practice now is to omit the 2. Thus the lowest temperature experienced by Scott, 213° A. (−77° F.) would be written 13° A., it being understood that the 2 precedes. It may also be well at this point to give some of the highest elevations made or deepest aërial soundings. At Pavia, Italy, 37.6 kilometers (23.4 miles) at Uccle, Belgium 33 kilometers (20.15 miles). The American record is 17 kilometers (10.5 miles).

Time	Pressure Kb	Pressure mm	Elevation Met.	Temperature Abs.	Gradient F/100 m	R. H.
7:00	1,001	751	100	290°	....	81
7:05 (?)	900	675	1,000	287	....	..
....	797	598	2,000	281	.056	..
....	705	529	3,000	275	.066	51
7:18	621	466	4,000	269	.042	34
7:20 (?)	547	410	5,000	264	.069	..
....	479	359	6,000	251	.086	30
7:34	313	235	9,000	234	.084	30
7:38	271	203	10,900	222	.065	..
7:44	199	149	12,000	216	.039	29
7:47:04[1]	168	126	13,040	213	.021	29
7:48	160	120	13,340	213	—.007	29
7:52	129	97	14,650	218	—.031	30
7:56	103	78	16,050	223	—.07	29
8:02	72	54	18,370	218	.01	29
8:12	36	27	22,720	222	.00	29
8:32	8	6	32,430	234	....	29

[1] Beginning of inversion.

Blue Hill Meterological Observatory

In recent ascents made at Batavia, Java, December, 1913, during the rainy season, a height of 26 kilometers (16.2 miles) was reached. Perhaps the best idea of the temperature fall for different months can be obtained from W. H. Dines in his table on Geophysical Memoirs 2.

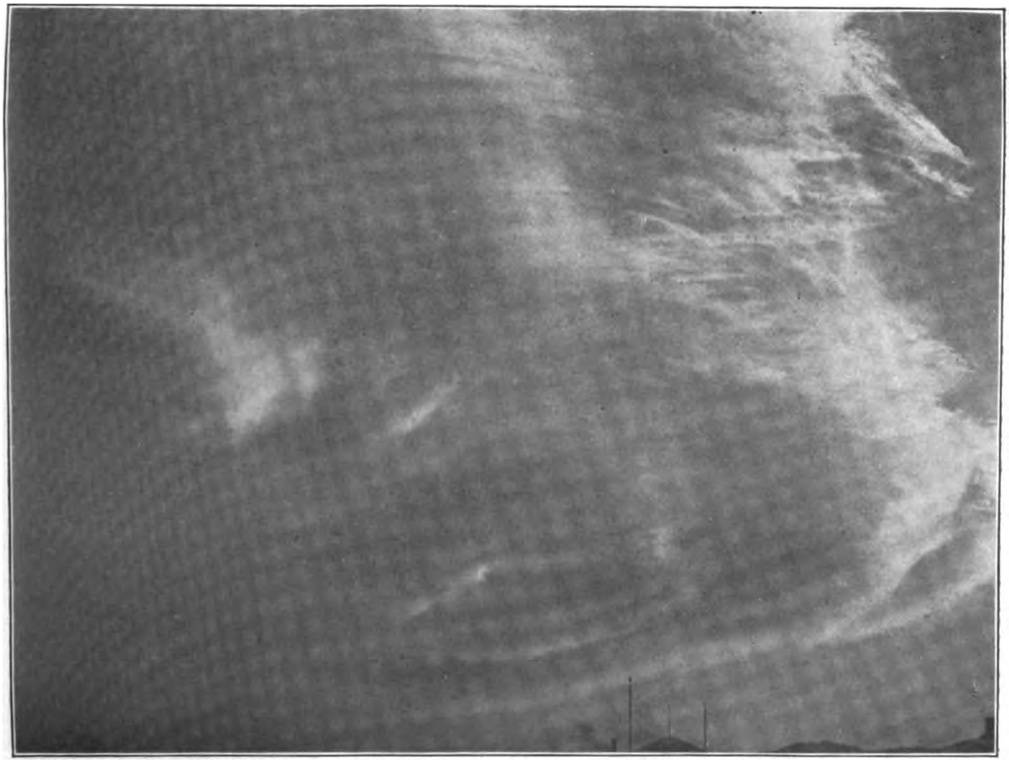
It is evident that the mean annual isotherm of 273° A., *i. e.*, freezing, which reaches at sea level in latitude 62° N. and S. is at the equator more than 5 km. (3 miles) high; also that above the equator the fall in temperature continues to a much greater height than in temperate

Kilometers	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
14	216	17	19	21	22	23	22	21	19	17	16	15
13	16	17	19	21	22	23	22	21	19	18	17	16
12	17	18	19	20	21	22	22	21	21	19	18	17
11	17	17	17	19	20	21	22	22	21	20	19	18
10	20	20	20	22	24	25	26	26	26	24	23	21
9	24	23	24	26	29	31	34	33	33	31	28	25
8	30	29	30	32	36	38	41	41	41	38	35	32
7	37	36	37	39	42	45	47	48	47	45	41	38
6	43	43	44	46	49	52	55	55	54	51	49	45
5	50	49	50	52	56	59	61	62	61	58	55	52
4	57	56	57	59	62	65	67	68	67	64	61	58
3	63	62	63	65	68	71	73	74	73	70	67	64
2	67	66	67	70	73	76	78	79	78	75	72	69
1	71	71	73	76	79	82	83	83	81	79	75	72
Ground	276	76	77	82	85	88	89	89	86	83	80	77

These values are for the British Isles. A more comprehensive arrangement is that of G. Nadler in a recent number of the *Beiträge der frein Atmosphäre.*

Cirro—cumuli

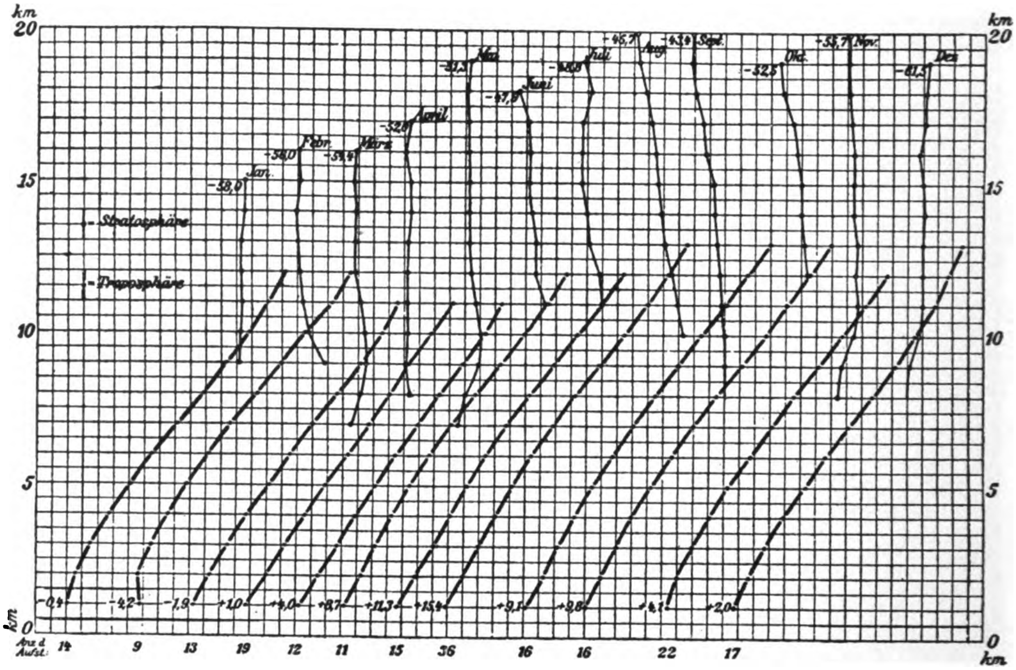
Cirrus—Ventosus (Windy Cirrus)



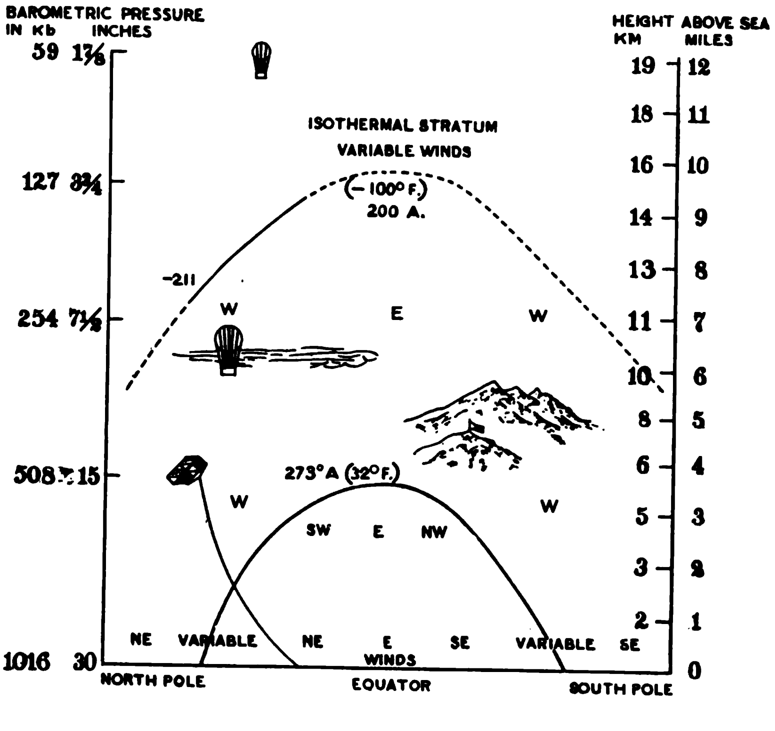
Whirling Cirro—stratus

regions; furthermore, that the lowest temperatures of the upper air are found above the equator. The work of Teisserenc de Bort and Rotch, beginning in 1905 with their well-known exploration of the air over the north tropical Atlantic, demonstrated that above the trades there was a change of wind direction, *i. e.*, above the northeast trade to southwest and above the southeast trade to northwest, the height of the plane of reversal varying greatly, while near the equator the wind was east at all heights. This has been strikingly confirmed by the recent Batavia, Java, records, when two sounding balloons entered the stratosphere at 17 km. (10.6 miles). On December 4, 1913, a temperature of 182° A. (−131.6° F.) was recorded. The balloon reached a height of 26 km. (16.2 miles) but from 17 km. upward there was a rise from 182° A. to 226° A. Now the average height of the stratosphere is 9.5 km. With a certain distribution of the water vapor, we find that this corresponds with a pressure of 250 kilobars, *i. e.*, practically three-quarters of the atmosphere is below this limit and in this radiation results in cooling while above the effect is a moderate heating. The minimum radiation temperature is approximately 214° A. or nearly the same as the lowest temperature experienced by Scott 213° A. (−77° F.). The temperature in the troposphere in equatorial regions may then fall 32 degrees lower than in temperate latitudes. Braak and others think that this may be explained by the pronounced vertical convection currents known to exist: and the different water vapor distribution.

In 1911, W. H. Dines, who has done so much experimental work, studying the relations between change of pressure at the 9 k. level and corresponding changes at the surface, advanced the view that inasmuch as the pressure variations were of the same order of magnitude, the



The figures beneath the diagram (*Anz. d.* and *Aufst.*) indicate the number of soundings upon which each monthly curve is based. The figures at the right and left express the altitude in kilometers, and those on the diagram itself, the temperatures in degrees C. For example, 15 sounding balloon ascensions in July gave average temperature of 284°A. (+11°C.) +11°C. at altitude one kilometer. The temperature decreased up to altitude 12 kilometers, and then remained almost constant, or increased slightly to altitude 19 kilometers, temperature 224°A. (−49°C.). And one readily sees that the beginning of the height of the isothermal region varies with the season. Fig. 2, drawn by Professor Rotch, gives the distribution of temperature over the globe, so far as known.



proximate cause of variation might be looked for at the level mentioned. It is the layer of maximum wind velocity just under the stratosphere and level near which is the most rapid change of temperature slope. In essence, a cyclone is produced by the withdrawal laterally of the air at 8–10 kms.

Shaw in his "Principia Atmospherica" (*Proceedings* Roy. Soc. Edinburgh, December 1, 1913), carries further the discussion of the relations of pressure and temperature in the upper air. In the stratosphere from 11 k. upward it is colder in the high pressure than in the low pressure at the same level; and in the troposphere from 9 k. downward it is warmer in the high pressure than in the low at the same level. He gives five laws which are briefly these:

1. Relation of motion to pressure.
2. Computation according to gaseous laws, especially $p = R\theta\rho$.
3. Convection.
4. Limit of Convection.
5. Saturation.

The postulates are

A. As given above, namely that in the stratosphere from 11 k. upward it is colder in the high than in the low; and from 9 downward it is warmer in the high than in low at same level and

B. The average horizontal circulation in the Northern hemisphere in January, between 4 k. and 8 k. consists of a figure-of-eight orbit from west to east along isobars round the pole with lobes over the continents and bights over the oceans.

The average circulation at the surface is the resultant of the circulation at 4 k. combined with a circulation in the opposite direction of similar shape, due to the distribution of temperature near the surface.

"SEASONING" CAST IRON

In the manufacture of the higher types of machinery, care is taken to lessen the cooling stress of iron castings by annealing or some other means, in order to make the iron homogeneous and less liable to breakage or distortion. This process is known as "seasoning." It has been found that in the case of ordinary test bars one inch square in section that there was a gain in strength of about 20 per cent. due to the shocks sustained during an hour in a tumbling barrel as compared with companion bars from the same ladle, not so treated. This phenomenon has become recognized and the American Society for Testing of Materials has revised its specifications for iron castings prohibiting the tumbling of test bars prior to testing. In the case of castings that cannot be well annealed by heating, an effect of softening may be secured by tumbling them while cool, or otherwise subjecting them to shocks, thus accelerating the removal of internal stresses by molecular movement. It is interesting to note that castings improve with age, owing to the slow or gradual escape of cooling stresses due to rearrangement of the molecules.

A GAS ENGINE SILENCER

Hiram Percy Maxim, inventor of the silencer for rifles, has produced a silencer for muffling other gaseous reports with special view to the silencing of the noisy exhaust of the gas engine. The device consists of a nested series of spiral cells between which are formed spiral whirl chambers which the exhaust must traverse. The silencing effect is increased by alternating the direction of the spiral whirl chambers so that the gases must travel alternately in a right-handed and in a left-handed direction. These chambers are larger as the opening is approached, to permit the gases to expand.

One of the particularly useful features of aeroplane reconnaissance is the fact that in looking down on a body of water from a great height, it is possible to see, plainly, objects at a considerable distance under water. The air-scout can not only see all the mines in a harbor with perfect distinctness, but they can easily be photographed from the aeroplane.

COLD LIGHT

An efficient cold or ideal light is far from being obtained commercially. Considerable progress, however, has been made in recent years toward this goal, and we anticipate still further progress in the near future.

The best method of comparing the efficiency of electric lamps is by comparing the light they give per unit of energy input, that is their lumens per watt, the lumen being the quantity of light which passes through a unit solid angle, emitted from a point source of one candle power intensity.

The maximum possible specific luminous output has been determined by several experimenters, but there is considerable variation in the values found. Drysdale and Nutting found the value to be around 200 lumens per watt, while Ives has calculated it as between 600 and 900, with the probability of 800 being the best value. These values are for that color light (yellow green of wave-length approximately 0.550μ) for which the eye has the greatest sensibility. A change in the color of the light makes a big difference in the luminous efficiency. For instance red light (.68μ) has a relative luminous efficiency when compared to yellow green light of only 2.6 per cent; yellow light (.59μ) 76 per cent; green light (.53μ) 91 per cent; blue light (.49μ) 23 per cent and purple light (.44μ) 2.9 per cent.

The following table shows approximately the relative luminous efficiencies of a number of our artificial lights.

These per cent luminous efficiency values are based on Ives determination of 800 lumens per watt as being the highest efficiency attainable.

Light Source	Spherical candle-power per watt	Lumens per watt	Per cent luminous efficiency
Hefner lamp			0.092 to 0.18
Carbon filament 3.1 watts per candle	0.26	3.3	.4
Gem filament 2.5 watts per candle	0.32	4.0	.5
Tantalum filament 2.0 watts per candle	0.4	5.0	.6
Nernst Lamp	0.50	6.3	.8
Osmium filament	0.56	7.0	.9
Moore vacuum tube	.63	7.8	1.0
Tungsten filament 1.1 watts per candle	0.73	9.1	1.14
Gas Filled Mazda lamp	1.2	15.0	1.9
Neon tube	1.4	17.5	2.2
Carbon arc enclosed 6.6 amp.	0.4	5.0	.6
Magnetite arc—6 amp.	1.3	16.4	2.1
White flame arc—10 amp.	1.8	22.9	2.9
Firefly			96.5
Yellow green light 0.545 μ wave length	65.	800.	100.

If the light source is an incandescent body, the maximum radiant efficiency possible to obtain would be when the body is between 6000° and 7000° abs., the radiant efficiency being the ratio of the energy radiated as light to the total radiated energy. Even then its efficiency is only about 50 per cent. At temperatures above 7000°, the maximum wave length moves from the yellow green toward the ultra-violet, the relative luminous efficiency consequently being much less. We must therefore turn to other sources, such as luminescent phenomena, which give off light without production of a large amount of heat, and which radiate selectively in the visible spectrum, for the true ideal light.

There is a large amount of work being carried out on fluorescent and phosphorescent materials, some of which (especially the latter) may give us an efficient luminous radiator.

Electro-luminescence, examples of which are the Moore tube and the Claude Neon lamp, already is being used commercially, although at present it is not extremely efficient.

In certain instances chemical action is accompanied with a production of light. The amount, however, is always so small that not much is expected along this line in the future.

Finally there is the light given off by certain bacteria, worms, fire-flies, etc. This latter comes nearest being the true cold light, and is what scientists are striving to duplicate.

R. C. ROBINSON.

SOCIOLOGICAL WORK IN FACTORIES

With the evolution of welfare and safety provisions on the part of corporations running model plants, a new force has entered industrial life. Not only is the condition of the workingman being appreciably bettered, but the manufacturers themselves find that they are making a distinct gain, sometimes in actual economy, and always in the contented service of their workmen which results.

The Welsbach Company, in its different plants, has established many safety measures, thereby minimizing its money obligations for accident. In their factories, gears, saws, belts, punch presses, knives and shears are covered. Grinding wheels are encased. For the general protection of health, buffers have the dust exhausted by suction fans, and workers are supplied with face hoods provided with wet sponges for the nose. Noxious acids are carried off by exhaust hoods; mantels, after collodionizing, are dried in closed chambers which carry downward vapors of wood alcohol and ether; blue glass plates are in use to protect the eyes from the intense glare occasioned by the hardening of the mantles. As the hardening rooms are excessively hot, and the processes of burning and hardening vitiate the air, they are supplied with fans to bring in cool air. Some of these fans supply fresh air to individuals as they work at their machines.

The company supports a hospital on its own premises with a nurse and a salaried doctor. It also keeps a limousine and an open car to carry accident cases to the hospital. All medical attendance and medicines are supplied employees gratis. The company goes a step farther and examines its men to ascertain their physical fitness for any work which subjects them to exceptional danger.

Considerable attempt has been made to beautify the grounds with shrubs and flowers, and to supply the employees, both men and women, with comfortable lunch rooms where good food is sold very cheaply, and with rooms where they may enjoy the privileges and comforts of club life. The young women have a piano in their club rooms; the men have a tennis court nearby. The women employees are now given five minutes for fresh air and relaxation twice a day. The cost of these recesses to the company has been estimated to be $2000 a year; but the result is actual gain owing to the refreshed vigor with which they continue exacting tasks.

Similar welfare work is carried on by a trained worker at the plants of the New Jersey Zinc Company. This company began its experiment in a small way with a Neighborhood House and Kindergarten. This Neighborhood House has since been enlarged. Classes of many kinds are held there, including such a range as folk dancing, hand work, and classes for foreigners' English. In this last class adult foreigners are taught technical terms which they need to know to carry on their work and to avoid accident, lessons in preventing accident to themselves, and the first aid to the injured. Here also they are encouraged to look forward to owning their own homes. Books, in several languages, and magazines are freely distributed. A gymnasium is maintained, and dancing under pleasant, wholesome conditions is encouraged, so that it is highly improbable that the cheap, commercial dance hall, with all its objectionable features, would appeal to the employees of this company who every Saturday night congregate for dancing in the Neighborhood House, often to the number of six hundred. The company moreover carries on a bank and two co-operative societies. The New Jersey Zinc Company does not intend that its welfare work shall offset good wages; it does claim that corporations doing welfare work do not fall below the scale. It also believes that the wage that is a fair one from the point of view of the value of a workman to his employer is not large enough to keep him and his family in anything more than the necessities of life. Books for his children, and suitable recreation, he cannot provide. The company considers that the body of

employees, who represent the composite labor of the corporation, should have, not as charity but as justice in business methods, the best it can afford to give them. E. T. S.

THE SMOKE NUISANCE

AGITATION for the abolishment of the smoke nuisance usually meets with opposition from the manufacturers who object on the ground that it would add to their expense to introduce smoke consuming devices. In view of the numerous anti-smoke crusades now going on, the following figures compiled by the University of Illinois Engineering Experiment Station may be of interest. A so-called "smokeless boiler" was used and the tests showed that the density of the smoke emitted was well within the limits of the strictest ordinance likely to be passed. The tests of efficiency were made with six different coals and each was tried in both the smokeless and the regular type of boiler. The detailed results of the test follows:

	Smokeless efficiency per cent.	Regular efficiency per cent.
With Iowa slack	47.1	39.5
Iowa slack	57.9	43.3
Illinois mine run	59.3	48.5
Illinois nut	67.0	56.1
Illinois lump	74.3	65.2
Pocahontas	74.9	57.2

TESTING PURITY OF SUGAR

A QUICK way of determining the purity of maple sugar, which has recently been put into practical use, depends upon the difference in electrical resistance of impure and pure sugar.

Standards of resistance were determined by sending a current through a solution of pure sugar, and then by making similar tests with sugar adulterated by the ordinary methods. It is not only a simple matter to determine whether the sugar is or is not adulterated, but the form of adulterant is also usually indicated by the degree of resistance.

RISK OF DEATH ON RAILROADS

IT has been computed that the average railway journey in the United States is thirty-four miles in length; and based on the number of fatal accidents, it is stated that a passenger might take 2,275,-122 such journeys with only one chance of being killed. At two trips per day this would require 3,792 years. If, for instance, the fatal accident should happen on the last day of the period, it would have been necessary for the traveler to start his program, of two trips per day, in the year 1879 B. C.

Science Conspectus

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VOL. IV 1914 No. 4

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

VOL. IV 1914 No. 4

RECENT ACHIEVEMENTS OF CHEMISTRY

A BRIEF SUMMARY OF NOTABLE DISCOVERIES AND DEVELOPMENTS IN THE FIELD OF CHEMICAL INDUSTRY—SYNTHETIC PROCESSES THAT ARE SIMULATING NATURE

AT THE Eighth International Congress of Applied Chemistry, Dr. Carl Duisberg of Eberfeld, Germany, read a notable paper on the latest achievements and problems of the chemical industry. Dr. Duisberg briefly covered the entire field of chemical endeavor, and from his address the following instructive excerpts have been taken:

Probably in no domain of human knowledge and endeavor have the combined forces of theory and practice, intimately acting and reacting upon each other, made such immense strides and led to the solution of such difficult problems as in the chemical industry, an industry which, indeed, had its beginnings in the distant past, but in its vast development and international character is essentially a child of modern times. Success has so emboldened this industry that it considers itself capable of solving any problem, provided the men in its service are well trained in theory and practice and ready to devote themselves to the best of their ability, with patience and perseverance, to the object in view. This has been shown by the struggle between the contact process of producing sulphuric acid and the old "chamber process"; by the rivalry between the Solvay process and the Le Blanc method in the manufacture of soda; by the production of nitric acid and its salts by direct oxidation of nitrogen of the air under the influence of the heat of the electric discharge; by the manufacture of ammonia from atmospheric nitrogen indirectly via calcium cyanamide, and directly by combination with hydrogen; by the replacement of madder by alizarine, and of natural by synthetic indigo, as well as by innumerable other instances in the color, perfume, and pharmaceutical industries.

If, before an audience not wholly consisting of chemists, I venture, within the brief period of an hour, to describe the latest achievements of the chemical industry and to recount the problems that are engaging our attention, I must restrict myself to a great extent both in the choice of the subject matter and its mode of presentation. We can, indeed, merely touch upon the most important happening in our industry and must, from the very outset, refrain from a thorough discussion of the subject, either from the purely chemical or the technical side.

In the spirit of Faust, "Who brings much will bring something to many," I invite you to make a flight with me in an airship, as it were, over the fields where the chemical industry holds sway, and, from our point of vantage, to make a bird's-eye view of the latest achievements of this industry. Now and then

we shall make a landing and examine the most attractive features a little more closely.

PRODUCTION OF POWER

The question of power, which is of the utmost importance in every industry, and especially in the great synthetic processes, by means of which nitric acid and ammonia are manufactured, is now dominated by the perfected utilization of hydraulic power and the development of the turbine. Not only does the transmission of electric energy render it possible to utilize water power at great distances, but it also allows of the transmission of power evolved at the coal mines and the peat fields to distant points, thus eliminating the necessity of transporting the fuel itself. Recently we also learned to apply the principles of the water turbine to the steam turbines. But this advance over the piston steam engine, which Watt so ingeniously constructed about one hundred fifty years ago, has already been surpassed by benzine, petroleum, or oil motors (Diesel motors), and, above all, by the reliable gas engines which are driven by blast-furnace gases, Mond gas, and more recently by peat gas.

PRODUCTION OF BY-PRODUCTS

The manufacture of by-products goes hand in hand with this more direct generation of energy from fuel. These products include ammonium sulphate, of such great importance in agriculture, and the tar distillation products, so indispensable in the color industry. The latest and most rational method of utilizing the peat or turf beds, which are so plentiful in Germany and in many other countries, is practiced in Schweger Moor, near Osanbrück, according to a process discovered by Frank and Caro. There peat gas is produced and utilized and ammonia obtained as a by-product, the required power being generated in a 3,000-horsepower central electric power station. The moorland, after removal of the peat, is rendered serviceable for agricultural purposes.

At that place nearly 2,500 to 2,600 cubic meters of gas, with 1,000 to 1,300 calories of heat, were obtained from 1,000 kilograms of absolutely water-free peat in the form of air-dried peat, with 45 to 60 or 70 per cent, of moisture. This gas represents energy equal to 1,000 horsepower hours, equal to 700 kilowatt hours, after deducting the heat and power used for the operation of the gas works. In addition 35 kilograms of ammonium sulphate were produced from the above quantity of peat, which contains 1 per cent of nitrogen

PRODUCTION OF COLD

Besides the problem of power and heat, the question of refrigeration is one of growing importance to the chemical industry. Instead of the ammonia machines with which a temperature of minus 20° C. can be attained, we employ today sulphurous-acid machines, or, better still, resort to the carbonic-acid gasifier, which yields a temperature of 40° C. below zero. It is hoped in the near future to produce refrigerating machines which, by the use of suitable hydrocarbons, will give temperatures of minus 80° C. Plants for the liquefaction of air, producing as low a temperature as minus 190° C., are becoming more and more common, and are especially profitable where gas mixtures, rich in oxygen, or where pure nitrogen, which are simultaneously produced, can be utilized. Diagrams showing the process invented by Linde for the rectification of liquid air with the object of isolating nitrogen and oxygen are exhibited here. The Badische Anilin and Soda Fabrik in Ludwigshafen on the Rhine intends to manufacture hydrogen from water gas in a similar way and to utilize the carbon monoxide, which is simultaneously obtained, as a source of power. In a large plant which is being erected the firm is going to produce ammonia synthetically by combining, according to Haber's invention, pure nitrogen, obtained by the liquefaction and rectification of air, with hydrogen manufactured as above.

MATERIAL FOR CHEMICAL APPARATUS

As regards the material for chemical apparatus, several new wares must be referred to:

Quartz vessels.—Apart from the fact that the saltpeter industry of Norway taught us how to absorb dilute nitrous gases in towers 20 meters high, made of granite, a substance which was rarely used for chemical purposes, we have today at our disposal tubes, dishes, and vessels of fused quartz, which are stable against acids and heat and which are manufactured in the same sizes and dimensions as the well-known earthen vessels.

Refined steel.—The greatest progress, however, has been made in the manufacture of iron alloys or refined steel.

Thanks to the kindness of Friedr. Krupp of Essen, I am in the fortunate position to describe a large number of hitherto unknown substances of great importance, of which I exhibit magnificent specimens, photographs, and lantern slides. Just here, however, I must ask you to make one of the landings from the upper air and permit me to deal with the subject at greater length. You will be astonished at the immense progress which has been made to the general benefit of our industry.

Of the greatest interest are the alloys of iron with other heavy metals and metalloids, *i. e.*, alloyed steel.

Instead of carbon, other elements are employed, which likewise enhance the hardness of steel, but prevent the formation of a crystalline microstructure liable to cracks and flaws. The most important of these elements is nickel.

Nickel steel.—The readiness with which nickel forms an alloy with iron has long been common knowledge. Even in Bessemer's days attempts were made in Great Britain to turn out cannon made of steel containing 2 per cent. nickel. The experiments were not successful because the nickel obtained at that time contained impurities, such as copper, arsenic, and sulphur, so that the steel could not be forged. Thirty years later pure nickel, as we know it today, made successful results possible. The same was the case with chromium, silicon, and manganese, and not until these elements were produced pure could successful alloys be manufactured with them, either alone or together with nickel. The chief aim in the manufacture of these alloys is the formation of an amorphous pliable structure of the steel. This result is attained not only by removing more or less of carbon, but above all by a certain thermic treatment, heating again and keeping it at a certain lower temperature. You will see two samples of steel; in the one case, the coarse crystallization of the pure carbon steel before it is forged, and in the other, the same steel refined by the thermic treatment. The difference in the microstructure of the forged carbon steel and that of the forged and thermically treated nickel steel must also be noted. While carbon steel, after forging, still shows a crystalline structure with visible cleavage planes of the crystals, the section of nickel steel displays an amorphous structure closely resembling that of welded iron. For comparison sake, a sample of a welded iron fracture is exhibited. It must not be overlooked, however, that nickel and chrome nickel steels are twice or three times as hard as welded iron. There are also exhibited test pieces of construction parts to be used in the automobile industry made of alloyed steel. Notwithstanding the high tensile strength of about 90 kilos per square millimeter (*i. e.*, about 55 tons per square inch), no fracture is noticeable, although they are greatly bent.

Aside from these improvements, which are of such great moment for structural steel, the iron alloys have found many new applications.

I merely mention the different nickel alloys for shipbuilding, electric appliances, and for valves. These valuable alloys containing 23 per cent. and more nickel, are nonmagnetic, and not affected by atmospheric influences; those containing 30 per cent. nickel possess great resistance to electricity, whilst the coefficient of expansion of steel with 45 per cent. nickel is only one-twentieth of that of ordinary steel and not greater than that of glass.

Chromium, tungsten, and molybdenum steel.—It is a very interesting and novel fact that by the thermic treatment alone the microstructure of the cheaper kinds of unalloyed iron plates and iron shapes is

so changed that it becomes three times as resistant to the destructive effect of acids. If alloys of iron with chromium, tungsten, molybdenum, and aluminium in certain proportions are thermically treated, this resistance is increased fivefold, as is shown by samples of ordinary carbon steel and chrome nickel steel which underwent a treatment with dilute sulphuric acid for 56 days.

An alloy of ordinary iron with 5 per cent. nickel is an excellent material for withstanding hot caustic soda. Most astonishing properties are displayed by steel alloys containing more than 10 per cent. of chromium and a small addition (2 to 5 per cent.) of molybdenum. Such alloys are manufactured in the form of malleable cast and forged iron pieces by Krupp according to the patents of Borchers and Monnartz in Aix-la-Chapelle and in the form of rolled tubes by the Mannesmann Röhrenwerken in Remscheid. These alloys are insoluble not only in dilute hydrochloric acid and sulphuric acid, but also in dilute nitric acid, even with the addition of alkalichlorides, and if they contain about 60 per cent. chrome, 35 per cent. iron, and 2 to 3 per cent. molybdenum they withstand even boiling aqua regia. You will see samples of this extraordinary steel, after treatment with acids, compared with ordinary steel and cast iron.

Tool steel.—It must be especially mentioned that the alloys of iron with chromium, tungsten, and molybdenum tempered by a special process invented by two Americans—Taylor and White—find most important uses as quick turning steel for all kinds of tools.

Vanadium steel.—The most recent improvements in the manufacture of steel for tools which must of necessity keep pace in hardness with structural steel have been made by the employment of vanadium. Unfortunately, this metal, the use of which is steadily increasing, is still very dear, and the problem which chemists have to solve is to produce it more cheaply. If the price could be reduced perceptibly, metallurgists prophesy a great future for this metal, which exercises a very favorable influence on the microstructure of steel.

Of great importance are those alloys of iron with chromium, tungsten, and vanadium, which possess a high degree of hardness even at 400 to 500° C. They are needed by engineers for the construction of steam turbines, for the embossing and spraying of metal objects when heated to redness, a process which has lately found extensive application. Chemists use these kinds of steel whenever chemical reactions are carried out at high temperatures and pressure, *e. g.*, for the synthesis of ammonia according to Haber's process.

The very latest alloy has now been patented and is being manufactured by Krupp for the construction of safety vaults and safes. This steel can neither be drilled nor exploded, nor can it be cut by the oxyhydrogen flame.

Two samples of steel are exhibited, one of ordinary steel in which great holes have been cut in five and one-half minutes by using an oxyhydrogen flame and in six minutes by an oxyacetylene burner, and a specimen of this new alloy which has remained intact after being treated with the same oxyhydrogen and oxyacetylene flames for one and one-half hours. Let us hope that on this hard and infusible material the scientific safe burglar will exercise his noble art in vain.

Manganese steel.—Of the alloys made with manganese, the manganese steel or hard steel, first produced by Robert Hadfield, because of its great wear, is chiefly for cast-iron parts of disintegrators and rails of electric tramways. On account of its hardness, this steel is not malleable, but it can be bent in the cold state, and is thus very safe against breaking. It is therefore of much interest to the chemical industry where, in almost all branches, grinding operations are carried out.

Silicon steel.—Finally I wish to refer to alloys of iron and silicon which contain 1½ to 2½ per cent. silicon and a high percentage of carbon. This steel is excellently adapted for tools and springs which must stand high strain. Since steel alloys containing much silicon, although brittle and porous, have proved very stable against acids, they are now being used

more and more where such a property is of importance.

Alloys with about 4 per cent. silicon, but very poor in carbon, are of greater value than the above. Robert Hadfield first pointed out the importance of this alloy, whilst Krupp, working in connection with Capito and Klein, a firm of fineplate rollers in the Rhineland, considerably improved it and introduced it for electric purposes. It is employed in large quantities in the form of sheets of 0.35 millimeter (1/70 inch) thickness for the construction of dynamos, alternatecurrent motors, and transformers. In Germany alone the consumption of this alloy already amounts to 8,000 tons a year. This material has a resistance to electricity four or five times greater than that of ordinary iron and loses only half as many watts, so that the injurious Foucault currents are reduced to a minimum. The manufacture of transformers has, therefore, become much cheaper, for the proportion between iron and copper is much more economical. The production of this silicon iron alloy, with its very low percentage of carbon, and that of the chrome nickel steels, almost free from carbon, became possible only after silicon and chrome, entirely free from carbon, could be manufactured by electric smelting processes.

Electro-steel.—Since the electric smelting furnace has come into use in the steel industry, the problem of removing the sulphur, which engaged the attention of chemists for so many years, has been solved. It has been found that the electric furnace process produces a slag free from metal, and such a slag is the prime requisite for the complete desulphering of the steel bath.

Electrolytic iron.—Superior to the silicon steel, poor in carbon, in its electric properties is the "Ideal" metal for electromagnets—the pure electrolytic iron—first produced by Franz Fischer, of Charlottenburg, and now manufactured by the firm Langbein-Pfanhauser & Company, Leipzig. Formerly it was impossible to produce it free from hydrogen, consequently it was hard and brittle and was not malleable. Only by electrolyzing at 100° to 120° C. and employing an iron salt solution mixed with hygroscopic salts, such as calcium chloride, the iron became free from hydrogen. Its hardness then sinks far below that of silver and gold and is not much greater than that of aluminium. It possesses the valuable property of becoming magnetic more quickly than ordinary iron, containing carbon or silicon, and also of again losing its magnetism more readily, thus considerably increasing the efficiency of electromotors, for which it is used. Amongst the exhibits you will find several objects made of this electrolytic iron; for example, a cathode made from an electrolytic iron plate during five days of uninterrupted operation; also plates made by rolling; further a motor which, if constructed of silicon iron, would furnish 0.5 horsepower, but being composed of electrolytic iron, though in use for several months without appreciable signs of war, it now furnishes 1.3 horsepower, in other words it is two and one-half times as efficient.*

With all these new materials at our disposal, among which I must also mention copper, with 10 per cent. silicon, and copper nickel, we shall surely be able to improve all sorts of chemical apparatus that suffer so much from wear and tear.

After this short invasion of the domain of metallurgy, we shall now turn our attention to the chemical industry proper, first dealing with the manufacture of inorganic substances, the heavy chemicals.

SULPHURIC ACID

The triumphal progress of the contact process for the manufacture of sulphuric acid in the United States scarcely has its parallel in Germany, where it originated. Platinum, in spite of the fact that its price has increased threefold, is still our principal contact agent. As it is possible to carry out other contact processes with various contact materials, we shall certainly find other agents than platinum available for sulphuric acid anhydride. It ought therefore to be a fruitful field for research to find cheap substitutes for platinum. The Americans, in the twenty

* See Zeitschrift für Electrochemie, No. 16, 1909.

years that have elapsed since Knietsch first successfully carried out the contact process, have increased their output three-fold for the same weight of platinum. Nevertheless, the old lead-chamber process still competes with the new method, and the steady improvement of this process and the purity of the resulting acid must be acknowledged. In fact, the lead-chamber process promises to make further progress in the future in view of the success of Falding's high chambers and Opls towers, in which large quantities of acid flow down.

The Gaillard tower is supreme for concentration and recovery of the acid and for the regeneration of the various waste acids.

AMMONIUM SULPHATE

A new way of manufacturing sulphuric acid, together with ammonia, from the gases which are produced by the dry distillation of coal, is looming above the horizon. Burkheiser is seeking, with the aid of especially prepared wet iron compounds, to bind the sulphur, simultaneously absorbing cyan, and to convert the ammonium sulphite thus produced into ammonium sulphate by oxidation with atmospheric air.

In competition with Burkheiser, Walter Feld is endeavoring to recover sulphur directly as ammonium sulphate by a series of interesting reactions, in which thiosulphates play an important part. Such plants are in operation in Königsberg and here in New York.

NITROGEN COMPOUNDS

So much has been written concerning the progress made in the last five years in the utilization of atmospheric nitrogen that I need not enter into a description of Kirkeland-Eyde's, Schonherr's or Pauling's process for the direct oxidation of nitrogen by means of the electrical discharge, nor of Frank-Caro's method of forming cyanamide from carbides (the world production of cyanamide is, according to Dr. N. Caro, 120,000 tons per year, of which 31,000 tons are manufactured in Germany [16,000 in Trostberg and 15,000 in Knapsack near Cologne], 19,000 tons are made in Niagara Falls by the American Cyanamide Company, and during the next three years the total production is to be increased to 200,000 tons), nor is it necessary to describe the Serpek process for the production of ammonia from aluminium nitrides combined with the utilization of alumina which is simultaneously obtained. I will mention, however, that the problem of concentrating the dilute nitric acid, as obtained in the large absorption apparatus from nitrous gases, has been solved by Pauling's method, in which sulphuric acid is used in a battery of towers. It is also possible now to convert economically cyanamide into ammonia and this again into nitric acid.

SODA AND CHLORINE

The fifty-year-old Solvay process, which has conquered the whole world, still remains master of the situation. This is all the more remarkable since it is still imperfect as far as the yield is concerned, for a quarter of the salt used in the process is lost as such, and the whole amount of chlorine in the form of calcium chloride.

Although the materials employed in the Le Blanc process are completely utilized, this fact will not give it any chance of surviving, and it would seem to be now chiefly of historical interest.

Not less remarkable is the twenty-five years' career of the alkali-chloride electrolysis. The limited market for chlorine compounds and the great space taken up by the electrolyzing baths were great obstacles to the progress of this apparently so simple method. For the same reasons the most approved processes, such as the Grieshiem cement cell, the quicksilver cathodes of Castner and his successors, the Aussig Bell and the wire-gauze diaphragm of Hargreaves, with its many varieties, of which the Townsend cell is the latest and best, did not develop as expected. The limited demand also quickly restricted the operation of the brilliant method of manufacturing chlorates by electrolysis.

TIN

Tin is not only produced from natural ores but also in more than twenty detinning establishments from tin plate and

tin-can waste; 200,000 tons of tin-plate waste are subjected to this treatment and about 24,000,000 marks ($6,000,000) worth of tin and iron are recovered. The electrolytic detinning process, on account of high wages, the great cost of current, and the considerable manufacturing loss, has been replaced—where there is a market for chloride of tin—by the patented process of Thomas Goldschmidt, of Essen. This process takes advantage of the properties of chlorine gas, in the dry state, to greedily take up tin without reacting on iron if certain temperatures are observed. Instead of the inferior quality of electrolytic tin mud, which must be converted into marketable tin by costly smelting operations, the new process yields an anhydrous tin chloride, which is used in large quantities for weighting silk. The detinning with chlorine is not carried out with cuttings, as in the electrolytic process, but with waste pressed in hard packages, so that twenty times as much material can be treated in the apparatus at the same time. In the United States this process is operated by the Goldschmidt Detinning Company of New York.

REDUCING AND OXIDIZING AGENTS

One of the most brilliant successes in applied chemistry has been achieved by the perservering experiments of some chemists with a long-neglected substance, the constitution of which had never been properly understood. The old hydrosulphite of Schützenberger, rendered stable and easily transportable in powder form as an anhydrous sodium salt or as rongalite in combination with formaldehyde, has now become a most important article of commerce. It is chiefly used in vat dyeing and for reducing purposes in general, such as stripping dyed fabrics and as decrolin for bleaching sugar.

PEROXID OF HYDROGEN, PERSULPHATE, AND PERBORATES

Peroxid of hydrogen and its derivatives at present find less favor in commerce, although their future appears to be very brilliant. Recently the Farbenfabriken vorm. Friedr. Bayer & Company succeeded in rendering this important oxidizing agent, which easily decomposes and which can be marketed with difficulty only in watery solution, solid and stable by the addition of urea.

This powder is in the market under the name of ortizon, but on account of its relatively high cost it is intended not so much for technical as for hygienic and pharmaceutical purposes.

The interesting manufacture of sodium peroxid from sodium and the many scientific investigations of the persalts, have not been followed by great commercial success. The persulphate and perborate, however, the latter under the name of "Persil," are being manufactured on a large scale. The reason of this failure seems to be the high cost of production.

RARE METALS

The most interesting alloys discovered by Muthmann and Auer have found little application in the arts, and the use of cerium and thorium preparations is still confined to the incandescent gaslight industry. Only the "Auermetal," consisting of 35 per cent. iron and 65 per cent. cerium, is employed and this only to a limited extent for the manufacture of pocket cigar lighters.

In the metal filament lamp industry, tungsten, which shows the highest melting point of all metals, namely 3,100°, has replaced tantalum, which melts at about 2,300°. This became possible only after successful experiments to render the metal ductile by hammering.

The elements cadmium, selenium, and tellurium are obtained in great quantities as by-products; the first is produced in the zinc industry, the other two from the Tellur gold ores which are found in Cripple Creek, Colorado. Although they are sold at relatively low prices, they find but little use in the industries.

ARTIFICIAL PRECIOUS STONES

Finally, I will, in but a few words, touch upon a new industry, viz., the synthetic manufacture of precious stones from alumina with additions of chrome oxide, iron oxide, or titanic acid. Artificial rubies and white, yellow, and blue

sapphires, which cannot be distinguished from natural stones, are being manufactured in great quantities in Paris and recently also by the Electrochemische Werke, Bitterfeld. They are used extensively for jewelry and especially as bearings in watches and measuring instruments.

All this will give you a striking picture of the development of inorganic chemistry, which is taking a more and more important position beside organic chemistry.

SYNTHETIC PERFUMES

In the perfume industry, the developments made since the scent of the violet was imitated with jonon, and since the successful synthesis of camphor from turpentine, are not of such nature that we need to deal with them at great length. The importance of this industry appears from its yearly turnover of forty-five to fifty million marks (ten to twelve million dollars). Here the efforts of the chemists are directed toward determining the constitution of the complex and simple natural perfumes, isolating the various products of decomposition obtained during the investigation, and finally reproducing the natural perfumes synthetically. Such results have already been achieved in the case of the odor of the rose, lily of the valley, and violet. Very often certain substances are needed in the compounding of perfumes, which, like indole, possess anything but a pleasant smell.

ARTIFICIAL SILK

Even if doubt be expressed as to whether artificial silk (the yearly consumption of which amounts to about 7,000,000 kilograms) still belongs to the chemical industry because it stands in such close relation to the textile industry, with its weaving and spinning machines, yet the raw materials needed for its production, such as nitrocellulose, copper ammonia cellulose, and cellulose-xantogenate, are of such importance that the chemist and engineer equally divide the responsibility in this branch of manufacture. Viscose silk from xantogenate of cellulose, the production of which has been recently very much improved, seems to replace nitrocellulose silk and the copper ammonia silk. This viscose silk surpasses all other artificial silks in luster and is the cheapest to manufacture, so that the apparently simplest process of all, the copper ammonia cellulose silk, cannot compete with it any more. Among the exhibits are fine specimens of this silk from the Vereinigten Glanzstofffabriken of Eberfeld and their factory in Oberbruch in Dremmen near Aix-la-Chapelle, including the various raw materials, wood, cellulose, alkali cellulose, and the cellulose xantogenates produced by treatment with bisulphide of carbon and the viscose solution itself.

ACETYLCELLULOSE-CELLIT FILMS

From the acetylcellulose soluble in aceton, called cellit, the Farbenfabriken vorm. Friedr. Bayer & Company first produced cinematograph films, but although they have the great advantage over those manufactured from nitrocellulose in being noninflammable, it has not been possible to introduce them generally. In all their properties the cellit films are equal to the old inflammable ones, yet the proprietors of moving-picture theaters do not take them up because they fear the competition of the schools and the home where the cellit films would be largely used on account of their noninflammability. The only help then would be such action by those in authority as to make it difficult to employ inflammable films and to facilitate the use of cellit films. There are prospects of such legislation at least in Germany, which would put an end to cinematograph fires with their great danger to life and property.

NONINFLAMMABLE CELLULOID (CELLON)

The problem of manufacturing noninflammable celluloid by mixing cellit with suitable camphor substitutes which burn difficultly or not at all may be considered as definitely solved. Eichengrün has simplified the manufacture to an extraordinary extent by showing that certain acetylcelluloses may be gelatinized

in the same way as nitrocellulose. As is well known, nitrocellulose with camphor in the presence of a solvent yields a so-called solid solution, and even in the dried state may be easily cut or formed into sticks, tubes, or threads. Cellit, when treated in exactly the same way with appropriate camphor substitutes, can be converted into "cellon," the non-inflammable substitute for celluloid. Single blocks weighing 200 pounds are already produced on a large scale which like celluloid can be sawed, cut, and polished; when heated can be pressed or bent; and when subjected to steam at a high temperature can be drawn and molded. Compared with celluloid, cellon has the advantage of being more elastic, soft, and ductile. It is therefore frequently used as a substitute for hard rubber, gutta percha, leather, etc. Cellon, in the form of a highly viscous, sirup-like solution, may be employed for coating fabrics, wood, paper, metal, etc., with a thick, enamel-like, uniform and pliable surface. Thus patent leather, artificial leather, insulators, balloon covers, etc., may be produced. In France this varnish is already employed for enameling aeroplanes. Objects made of this novel and widely useful material are to be found among the exhibits being manufactured by the Rheinisch-Westfalische Sprengstoff Actien Gesellschaft in Cologne and the Société Industrielle de Celluloid in Paris.

RUBBER

Finally, I will refer to one of the greatest successes and yet one of the most difficult problems of the chemical industry, viz., the production of synthetic rubber. I am proud of the fact that its production was successfully accomplished in the works which are under my management, and that I was able to follow every stage of this important discovery. Perhaps you would be interested to hear how the whole thing happened, especially as much that is untrue and misleading has appeared in the press during the last few weeks.

But first, a few words about the natural rubber. The Old World owes its knowledge of this substance to the New. This wonderful product became known in Europe shortly after Columbus discovered America. If I, coming from across the ocean, now bring you this colloid prepared there synthetically, I merely repay part of the debt which we owe America.

Hardly a generation ago, the southern part of this great American continent furnished the whole supply of the different kinds of rubber. Since then extensive plantations of rubber trees have been established in various tropical countries, and their yield has grown so enormously that the old home of wild rubber will soon be thrust into the background. This is a matter which involves many millions; consequently a very serious economical problem confronts South America.

You all know that caoutchouc is made from the milky sap of numerous species of trees and shrubs and the grotesquely formed lianas by various coagulation processes, and that this product, on being suitably treated with sulphur or sulphur compounds, *i. e.*, by vulcanization, acquires its valuable and characteristic properties. The synthetic method took quite a different route. By breaking up the very complex molecule which rubber doubtless possesses, by pyrogenetic processes, *i. e.*, by dry distillation, a veritable maze of all kinds of gases, oils, and resins was obtained, as well as a colorless fluid resembling benzine, to which the investigators gave the name of "isoprene." It was Bouchardat who first expressed the belief that this isoprene, which is obtained in very small quantities and in an impure form by the dry distillation of caoutchouc, might be closely and intimately related to caoutchouc itself. This important question was then eagerly discussed for several decades by the scientists of all countries, and opinions were sharply divided.

As far back as the eighties, Tilden claimed to have prepared artificial rubber from isoprene by treatment with hydrochloric acid and nitrous acid. But neither Tilden nor his assistants, though they worked strenuously for years, succeeded in repeating the experiments. Moreover, numerous other investigators, among

them our chemists, were unable to confirm the results. In 1894 Tilden found, however, that that isoprene which he had prepared about ten years before, on standing, had partially polymerized into rubber. In this way Tilden, in fact, was the first discoverer of synthetic rubber. But this method, which time has not yet permitted to repeat, is obviously not a commercial one. Dr. Fritz Hofmann of the Farbenfabriken vorm. Friedr. Bayer & Company is to be regarded as the real inventor of synthetic rubber, for, by the application of heat, he succeeded, as the first, in August, 1909, in polymerizing the isoprene molecules completely into the complex rubber molecule on a technical scale. Somewhat later Harries invented independently another method of arriving at the same result. Everyone is now in a position to repeat this exceedingly simple experiment himself, but in order to confirm Hofmann's results, it is necessary to employ pure isoprene.

The practical value of this rubber, of which many samples are among the exhibits, has been tested by the highest authorities in this branch of the industry, whilst Prof. Karl Harries, whose unremitting labors, extending over many years, prepared the soil for Hofmann's synthesis, has carefully examined the chemical constitution of the substance.

Isoprene belongs to the butadienes. It was therefore to be assumed at the start that betamethylbutadiene would not hold a peculiar and isolated position amongst the butadienes in general. It was argued that other members of this interesting group of hydrocarbons would yield analogous and homologous rubbers on being heated. In the synthesis of products occurring in nature, there is always a possibility of producing such variations, and our endeavors to find out whether this was true in the case of rubber were crowned with success, for today several representatives of the new class of caoutchoucs possessing different properties are known and are being submitted to technical tests. Exact proof of the existence of the class of isomeric and homologous caoutchoucs was also first presented by Eberfeld.

To you who hear this account and see these beautiful specimens, the matter appears very simple, intelligible, and clear. In reality, however, it was not so. The difficulties which have been overcome were great indeed and those which still remain to be surmounted, in order to produce a substance equal to Para caoutchouc in quality and capable of competing with cheap plantation rubber costing only two marks per kilo, are still greater. But such difficulties do not intimidate the chemist and manufacturer; on the contrary, they spur them on to further efforts. The stone is rolling, and we will see to it that it reaches its destination. The end in view is this, that artificial rubber may soon play as important a rôle in the markets of the world as does natural rubber. The consumption of rubber is simply enormous. Finished articles to the value of three milliard marks ($750,000,000) are manufactured every year, and the raw material from which they are made, calculated at the present market price of twelve marks ($3) per kilo, costs one milliard marks ($250,000,000). Other tasks which the chemist has on hand shrink into insignificance compared with this gigantic problem. The laurel wreath will not adorn the brow of the wild dreamer but that of the scientist who, cool and persevering, pursues his way. The seed he sows ripens slowly, and though, according to the statements in the press, all this is mere child's play and the problem has been solved, I leave it to your judgment whether this is true or not, like much that printer's ink patiently transfers to paper. I am right in the midst of this excitement. I have employed articles made of synthetic rubber and for some time I have used automobile tires made of this material. Yet, if you ask me to answer you honestly and truly when synthetic rubber will bring the millions which prophets see in its exploitation, I must reply that I do not know. Surely not in the immediate future, although synthetic rubber will certainly appear on the market in a very short time. I hope to live long enough to see art triumph also over nature.

We are now at the end of our journey. We have flown not only over the field

of Germany, but also over all other countries where the chemical industry is cultivated. We have taken a passing glance at the untiring striving for advance, the restless search for the hidden and unknown, the ceaseless efforts to acquire more technical knowledge, as witnessed in the great laboratories and factories of our mighty and ever-growing industry. We will now guide our airship into the haven whence we set out and land where our co-workers have gathered from all the countries of the earth to recount whatever progress each has achieved and to discuss, in public and private, the problems which have been solved and those which still await solution.

A REMARKABLE ORGAN

A remarkable development with organ pipes by an alumnus of the Massachusetts Institute of Technology has been the installation of an 128-foot stop in an organ in Lowell. This he calls the *Tonus Infra Totissima*, and its lowest pipe is CCCCCC, according to the symbols of musicians. It has been produced by William B. Goodwin, '79, a man of means, who, from pure love of the work, began the study of organ construction, which has now become his profession. The city of Lowell is remarkable in the number of fine organs that it possesses, and the quality of a number of these is due to the work and advice of this student of music.

It is not so long ago that the 32-foot pipe was the lowest tone to which makers could go. The great organ which a generation ago was the pride of old Music Hall in Boston, was notable in that it had a stop of these great pipes in its front. The lowest note (CCCC) vibrates at the rate of sixteen a second, and this being very nearly the point below which the vibrations cease to form continuous sound, it was believed that the practical limit had been reached for organ pipes.

Within the past twenty-five years much has been added to the knowledge of organ building and the electric action has been no small factor in the advance. It has relieved the key of the cumulative weight of stops as they are added, a failing of the old tracker organ action, and has permitted new combinations of strength and beauty, impossibilities in earlier days.

It was a daring explorer into the "tombs of sound" who a few years ago ventured on a stop of 64 feet, CCCCC, *Tonus Profundus*. This was done in Sydney, and a stop of full-sized reeds is there to be heard.

It is well known that quality of tone, the factor that makes the violin different from the flute, is dependent upon the selection and proportionate strength of the overtones. Those who have had the pleasure of listening to the recent lectures of Professor Dayton C. Miller of Cleveland have heard for themselves how a number of independent organ pipes (representing the overtones), when sounded together, produce thus synthetically the quality desired in the resultant tone. In the same way, the overtones that give the quality to the *Tonus Profundissimus* may be assembled in an organ and thus it is that the effect of it is produced without the necessity of using a pipe of that length. Synthetic 64-foot stops are now to be heard in a score of organs the world over.

The advance that Mr. Goodwin has made is even more remarkable, for in the 128-foot stop the lowest C vibrates only four times a second. It is this that he has introduced into the organ of the Immaculate Conception in Lowell, the *Tonus Infra Totissima*. The stop is described as "a mighty atmospheric throb of most awesome majesty, which, while soft, is so pervasive as to hold its own against the mightiest crashes of the full organ." It is true of course that these grave and "remote" tones have their place only in slow and solemn music, such as the recent reversion to the Gregorian encourages.

The Immaculate Conception organ has long been known as a fine organ. Some time ago the provision made by its builders for a 32-foot stop was fulfilled. Since that time a 64-foot stop has been added, and today it is unique in having the 128-foot, a pedal stop that is an octave lower than any other in the world. J. R., JR.

DURABILITY OF CONCRETE IN SEA WATER

SOME INTERESTING EXPERIMENTAL TESTS OF THE EFFECT OF FROST AND SEA WATER ON VARIOUS CONCRETE MIXTURES UNDER DIFFERENT CONDITIONS

It has long been considered that the combined action of frost and sea water in northern climates would be fatal to the long life of concrete structures. To disprove this theory, twenty-four 16 foot concrete piers or specimens were made in January, 1909, by the Aberthaw Construction Company, and have been subjected since that time to the rise and fall of the tide in the Boston Navy Yard.

They are so placed that the salt water rises nearly to the top of each specimen once in twelve hours, while six hours later it drops nearly to the bottom of the specimen. In cold weather the specimens are thus alternately frozen and thawed. Some of the specimens were mixed so lean in cement that they were necessarily somewhat porous, and it must be considered that any porous masonry subjected to this treatment would show spalling. Others, however, richer in composition, are still in almost identically the same condition as at first. It is evident, however, that only long years will show whether any of the specimens will prove permanent.

The first three specimens were made of one part cement, one of sand, and two of stone, and mixed dry, plastic, and very wet, respectively. The next three were made of approximately one part cement, two of sand, and four of stone, but so proportional after mechanical analysis of materials that the excess of cement over voids of sand should be 10 per cent. and the excess of mortar over voids of stone should be 10 per cent. These three were mixed dry, plastic, and very wet, respec-

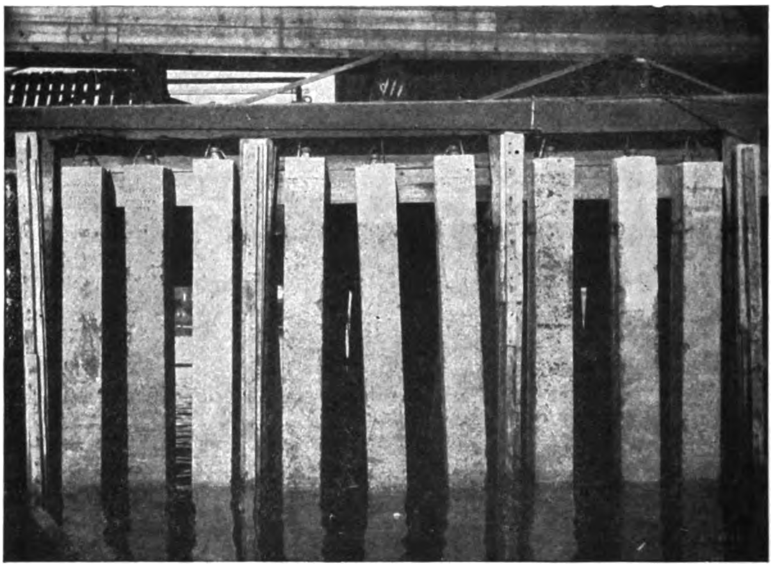


Fig. 1. This view shows nine of the piers at almost low tide. It gives an indication as to the original method of support

tively. The next three were made of one part cement, three of sand, six of stone, and mixed dry, plastic, and very wet, respectively.

Ten samples were made in pairs, one of each pair being mixed 1 : 1: 2 and the other 1 : 3 : 6. All of these were mixed wet. Two were made from a Portland cement practically free from iron; two of a commercial Portland cement high in alumina; two of a commercial cement low in alumina; two of an iron ore cement practically free from alumina; two of slag cement.

The other five samples consisted of one part cement, three of sand and six of stone, and were mixed wet. They were intended to show the effect of waterproofing on a porous concrete. Number 20 was most thoroughly well mixed—much better than commercial mixing. Number 21, which was mixed with salt water instead of fresh water, was lost in handling in 1912. Number 22 had one-tenth part by weight of hydrated lime substituted for an equivalent amount of the cement, thus making the mixture really 0.1 hydrated lime, 0.9 standard Portland cement, three parts sand, six, stone. Number 23 was mixed with a Sylvester solution of soap and alum; number 24 contained finely pulverized clay to the amount of 5 per cent. of the weight of the cement.

Between periodic inspections, the specimens are hung under the cap log of one of the wharves in the Navy Yard, as shown in figure 1. Each specimen measures about 16 inches square in section and weighs a little more than 4000 pounds. The weights per cubic foot in the different specimens vary from 142 to 152 pounds.

Illustrations are given of four typical samples photographed in December, 1913. The extent of action is indicated in each of the photographs.

Figure 2 represents specimen No. 1, which was rich in cement but cast very dry. The face, as shown in the photograph, was badly eroded for the full length, but the sides and back were probably as good as when the pier was poured.

Figure 3 represents specimen No. 3. This was the same mix as specimen No.1, but it was cast very wet, the concrete

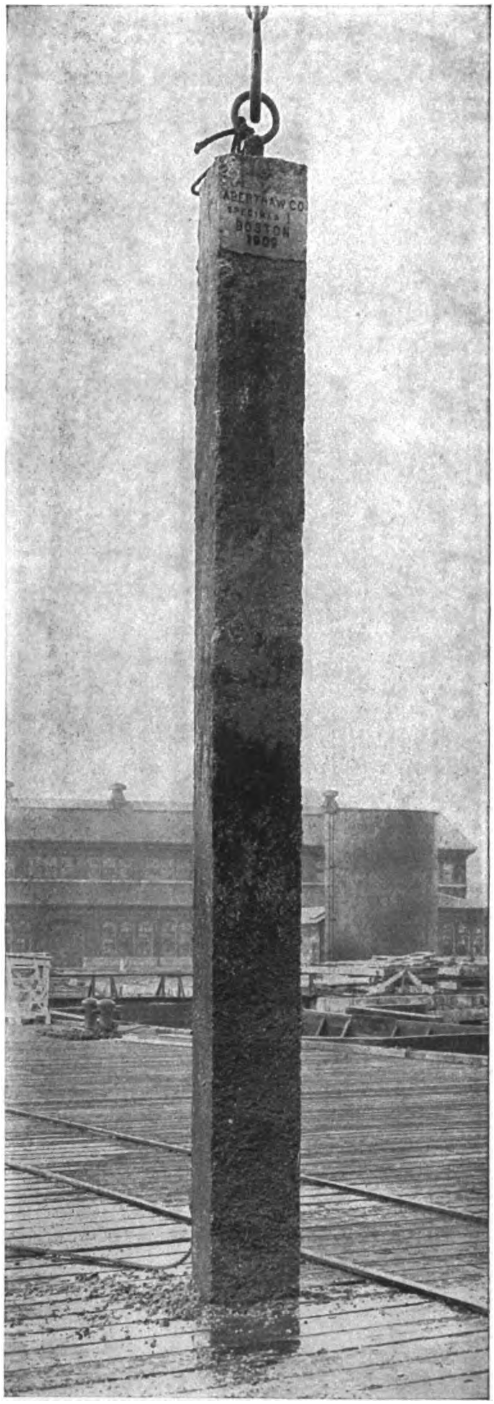


Fig. 2

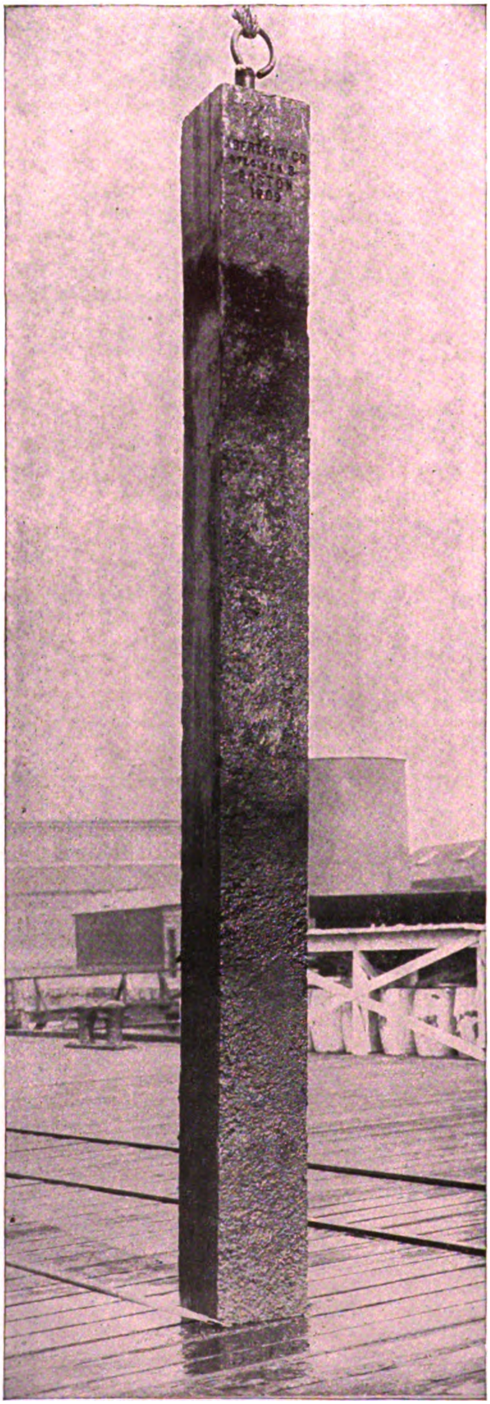


Fig. 3

Fig. 4

being soft enough to run out of an overturned barrel, but it would not flow like syrup. Although this shows a slight pitting action on both the face and the back, yet the greater part of this specimen is as good as it was originally.

Figure 4, specimen No. 19, shows the corners badly eaten away. This was very lean in cement, being mixed one to three of sand to six of stone. The cement used in this specimen was made from slag. The corners are all gone, several inches deep in some places, and the back is badly eaten, partly exposing the steel reinforcement in places. The concrete is soft and crumbly, although in the lower portion, where the specimen was continually immersed, even at low water, the condition is very fair.

Figure 5, specimen No. 18, also made of slag cement, but very rich in cement—1 : 1 : 2, has stood up splendidly under the test. It is good all over, the corners still being sharp, only a slight pitting action noticeable on the back.

Although no final conclusions can be drawn, it is interesting to note that those specimens which have shown the best results have been richest in cement and were mixed quite wet. Correspondingly, those specimens which have shown the poorest results have been lean in cement and mixed quite dry. All the specimens were cast horizontally, with reinforcing bars running the entire length near two opposite corners. They were allowed to season six or seven weeks before being hung in the water.

It should be noted that the cuts have been made from photographs which have not been retouched.

In a paper by Hess, of the Vienna Radium Institute, he tells of his investigations, by means of balloon ascents, of the penetration of radiation which occurs in the upper atmosphere. He states that at 2,000 meters the penetrating rays rapidly increase. He concludes that they cannot come from the earth, or the air which has its origin in the earth, but must be derived from some extra terrestrial source.

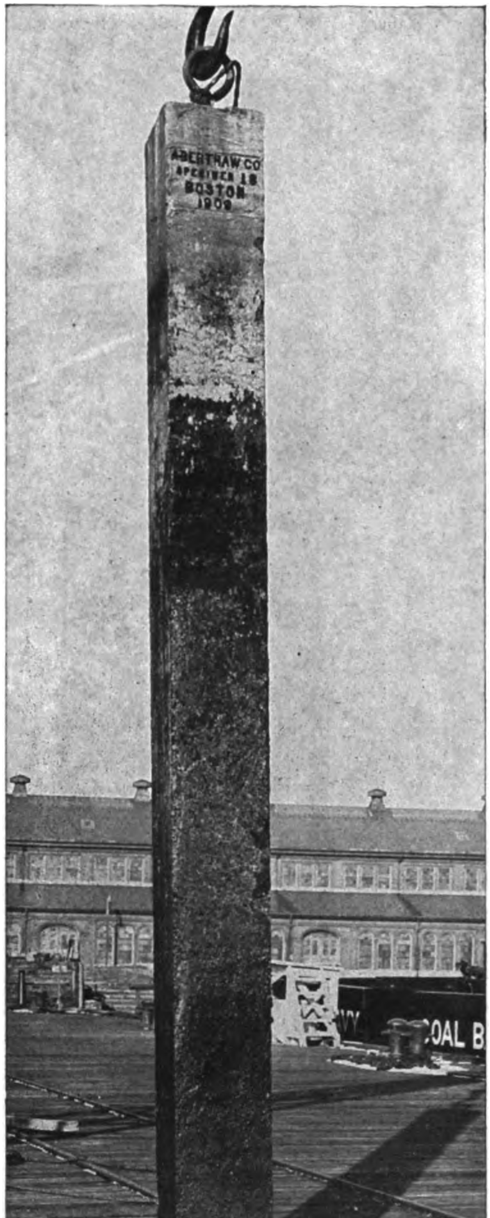


Fig. 5

WONDERFUL USES OF THE GYROSCOPE

THE first article in the first number of SCIENCE CONSPECTUS was on the subject of the gyroscope by Elmer A. Sperry. In that article Mr. Sperry referred to his gyroscopic compass, which he was then experimenting with, prophesying its wide use, when further perfected, especially in the Navy, and he also touched on the possibilities of the gyroscope as an aëroplane stabilizer. Since that time, Mr. Sperry has been assiduously working on both these problems.' A few compasses were then in practical use and since that time they have been installed on many of the larger United States warships.

It is a well-known fact that the magnetic compass does not point to the true north, but varies with the seasons, and there is also a diurnal variation. In addition to that there are local disturbances which make it necessary to adjust compasses with great exactness, and also to provide for variations. Although the gyroscope has also its variations, the new Sperry apparatus is so devised that it holds exactly true to the geographical meridian, requiring no correction factors and no correction tables.

Announcement was recently made that Mr. Sperry and his son had startled French aviators by the remarkable stabilizing properties of their gyroscopic apparatus for aëroplanes. The idea of using the gyroscope for this purpose is very old, and has been experimented on by a number of people. Mr. Sperry's application of the gyroscopic principle, however, is an entirely new one. He does not attempt to actually stabilize aëroplanes by the gyroscopic principle. When a gust of wind strikes any part of the guiding planes, the gyroscopes move in opposition, and in so doing operate a delicately balanced valve in the air supply line, which, acting on a piston, pulls or pushes the required lever, thus operating the ailerons or wing tips of the plane at the end of the tail. If there were no tempering arrangement to perform these operations with something approximating intelligence, the movement of the aëroplane thus acted on quickly and positively might, at times, throw the operator out of his seat, when the wind pressure was excessive.

Mr. Sperry has cleverly introduced here an anemometer; that is, a wind-measuring device. When the wind pressure is great, the anemometer operates to raise the fulcrums of the levers, so that the movements of the wind tips or tail planes are reduced in scope. The spinning gyroscopes are operated by a little dynamo driven by a belt from the crankshaft of the engine.

The exhibition of the Sperry automatic stabilizer in France won the French War Department prize of $10,000, offered for apparatus for increasing the safety of flying machines. The following is an interview with Rene Quinton, president of the National Aëroplane League of France, who went up with Mr. Sperry.

"Mr. Sperry and I started about noon in very unfavorable weather. The wind was so strong that the water of the Seine was very rough. Just after starting, the pilot began to ascend, and in a few minutes he let go the wheel. As we passed in front of the stand where the members of the committee were, he lifted both hands in the air. I, of course, being close to him, was already assured that he was touching nothing with his hands.

"The aëroplane still continued to go up. We were hundreds of feet above the trees. I could see the branches waving wildly in the wind, the heavy boughs being bent by the force of the gale, but it had not the slightest effect on the automatically controlled machine. I felt as if we were in an ordinary machine in perfectly calm weather.

"When we reached a height of about 800 feet we volplaned without the aid of the hand control. It is known that when aviators want to volplane they have to shoot the machine almost straight

down for a while in order to get the necessary speed when the motor is shut off. Could the Sperry machine do this without the aid of human guidance? Mr. Sperry proved that it could. He told me what he was going to do, stopped the motor and lifted his hands in the air. For five or six seconds nothing happened. The aëroplane seemed to be motionless. Then, suddenly the speed diminished and the machine dived like a dolphin.

"Then Mr. Sperry showed me another trick of his machine. We flew for nearly half a mile with the machine inclined at an angle of forty-five degrees. Sperry never touched the machine with his hands. The machine guided itself and it is worthy of remark that in this abnormal position, furious gusts of wind had not the slightest effect on its position. It defended itself automatically against the breeze."

After Quinton had made his flight, Sperry went up with a United States naval lieutenant, retired, who, as representative of several United States naval attachés to foreign embassies, flew the machine with the aid of gyroscopes. He never before had tried to pilot a machine, but as all he had to do was work the rudder, he made with ease a flight which, if performed a few years ago by a man who had given his life to aviation, would have won worldwide applause. It was blowing as hard during this flight as during the others.

One of the great advantages of the stabilizer is shown when banking on a turn. In machines manipulated by the ordinary hand controls, it is necessary when turning to use three controls which govern the rudder, the lateral dip of the machine and the fore and aft rise or fall. It is the complexity of this movement which makes it dangerous in the hands of a novice. But with the stabilizer it is only necessary to turn the rudder; the gyroscopes do the rest.

Once, young Sperry and his mechanic, Emile Cachin, climbed up into the air above the Seine, and the mechanic walked out upon a wing as calmly as if strolling upon the earth. The stabilizer kept the flying boat in a horizontal position. The mechanic tried to disturb the equilibrium of the machine, but the gyroscope would not permit it.

CRACKING OF BRONZE RODS

It often happens that some alloys of copper, which have been worked cold, unaccountably crack, sometimes merely on the surface and sometimes entirely through the cross-section of the piece.

In the building of the Catskill aqueduct several kinds of bronzes were used, principally manganese, Tobin and naval bronzes, the quantity of manganese bronze being largely in excess of the others. In this work an immense number of seats, valves, bolts, anchor rods, etc., were used, and it was discovered that hundreds of them, when assembled, were found to be circumferentially cracked. This caused a great deal of alarm and the subject was given a close study by the engineers in charge. It was found that those specimens that had been incidentally or deliberately annealed in the course of manufacture semed to have escaped from this trouble. It was also found not to be peculiar to any one kind of bronze but apparently affected those pieces that had been worked cold and had not been annealed. It was found that the cracked bronze was much harder than the material that did not crack. The theory was evolved that this season cracking was due to the initial stress of the metal augmented by the stress introduced by changes in temperature. These investigations have led to a series of standard specifications for such metals, which will, no doubt, avoid the serious menace of failure of pieces doing important duty.

EYE-PRESERVING SPECTACLES

In a paper recently read before the Royal Society of London, Sir William Crookes described a method of making glass for spectacles which will cut out the injurious ultra-violent rays of the sun in tropical countries. By another formula, glass spectacles are made to protect the eyes of glass-blowers by cutting off 98 per cent. of the heat rays.

COMMERCIALIZING OZONE

Ozone of any quality or quantity is now procurable. It is not possible to store this gas, but it can be manufactured by the use of any one of several types of ozonizers suited to the different purposes to which ozone is put. Two properties govern its use; its instability, and its insolubility in water in the ordinary sense of the word. The latter necessitates long and very intimate mechanical contact, which means special apparatus.

Ozone is a strong oxidizing agent, and if brought into close contact for a sufficient length of time causes complete sterilization. It is an excellent agent for purifying water. The amount necessary for ordinary water is very small. The length of time required naturally depends upon the degree of impurity. Wine has been ozonized in an attempt to age it artificially, but with poor results. Milk, likewise, cannot be successfully ozonized, although the futile efforts to treat milk on the part of Tindal and Schneller of Holland led to the discovery of this method of purification and sterilization of water.

Ozone actually burns up most of the organic matter in water. The latter after treatment is not only perfect from a bacteriological standpoint, but has no unusual taste, no odor, and no discoloration. The first bacteria to yield to ozone are the most dangerous pathogenic ones, including the typhoid bacillus and the cholera vibrio.

Ozone has been used in some schools and public buildings to purify the air. Its value for this purpose is much disputed. It is a question whether it does more than mask the unpleasant odors due to respiration, perspiration, and so on. Those who favor the use of ozonizers for purposes of air purification declare that it is these odors which prevent people in a close room from breathing deeply enough and that the destruction of the odors, harmless though they may be in themselves, is of value for that reason. In any case, the concentration of ozone, where used for this purpose, must be exceedingly low, since its powerful oxidizing action would be liable to injure the delicate character of human mucous membranes. The value of this gas as a therapeutic agent in cases of phthisis in early stages, anemia and obesity is also much disputed. Some claim that ozone will never become of therapeutic value, owing to the belief they hold that all of it is destroyed before it reaches the lungs; others maintain from their own observation that there actually is an increase in the oxyhæmoglobin percentage, which would not be the case if all the ozone had been absorbed by the mucous membranes.

Considered as an asset to the industrial arts, the cost of production in most cases has seemed so far to seriously limit its value. But this is an extensive field for investigation. As a bleaching agent it is obliged to compete with chlorine which is both cheap and efficient. It seems possible that some means may be found to increase the present yield of ozone to far more than ten grams per kilowatt hour, the highest yield at present. Ozone distinctly surpasses chlorine, however, when it is a question of the quality of the product. Paper pulp treated with a weak application showed a length of fiber several times that produced by chlorine bleaching. To the trade this is a very important feature, inasmuch as upon the length of fiber depends the amount of filling it is possible to add to the pulp in order to obtain a given weight of paper. Cotton and beeswax have been bleached by ozone. The latter requires a great deal of ozone due to the large amount of organic matter that must be destroyed. Sugar cannot successfully be bleached by this agent since the process interferes somewhat with crystallization. Glue loses its sticking properties. Yet flax has been well treated with ozone, for flax contains glue, the adhesive properties of which were destroyed by the treatment. Flour subjected to ozone retains a dis-

agreeable taste. The oil industries require a large amount of ozone, a fact which renders the expense an objection; but the prospects are that the elimination, by its use, of taste and smell will go far to counterbalance this drawback. Ozone also promises good results in the production of varnish from linseed oil in the improved transparency of the article. This is due in all probability to the fact that the oil has not been subjected to a high temperature. This process, moreover, dries oil for linoleums with considerable saving of time.

The theoretical yield of ozone is a thousand grams per kilowatt hour. In the highly probable event of a large increase in the present yield, it is easy to see from what has already been shown by experiment that ozone might revolutionize certain industries. E. T. S.

STATUS OF THE ELECTRIC FURNACE

In a recent bulletin of the Bureau of Mines, Mr. Dorsey A. Lyon of the department discusses the electric furnace for making iron as compared with the blast furnace. He states that the former is not yet developed as a competitor of the blast furnace. The feasibility of smelting iron ores in an electric furnace depends on the relative cost of blast furnace fuel and of electric power. Only hydro-electric power is used for operating electric iron furnaces at the present time. In general, there are few localities where the electric smelting of iron ores would be feasible with the electrical energy costing annually more than twenty to thirty dollars per kilowatt-hour.

The aspects of electric furnace steel plants are presented by Mr. Robert M. Keeney of the Bureau, who states that the cost of power does not enter so largely into the final result as it does in some other electro-metallurgical processes. Plants can be operated successfully under a power cost of one cent per kilowatt-hour in localities where the material can be obtained at the price common to other processes. Mr. Keeney states that since the advent of the electrical furnace it has been slowly adopted for refining steel. For the complete refining for the highest grade of steel, the electric furnace is now thoroughly established in Europe. Any product that can be made by the crucible process can be made with the electric furnace, and in most cases with cheaper raw materials and at a lower cost; also by the use of the electric furnace it is possible to make complex alloy steels with precision. The report seems to show that with a larger use of the high grade refined steels, the electric furnace will have greater vogue.

There is a demand throughout the country for a high grade of rail and structural steel at an increased price over acid Bessemer or even the basic open-hearth product. Electric furnaces cannot, however, compete with the old processes for making present grades of steel. It is in combination with either the Bessemer or open-hearth process that it seems destined to be prominent in the future.

A WIRELESS DANGER ABOARD SHIP

A circular recently sent out by the United States Bureau of Navigation calls attention to the danger of improperly insulated wireless apparatus on shipboard.

The operation of the radio-apparatus generates in the antennae enormous potentials or very high voltages. Any defect in the insulation causes electric sparks to pass over the insulator in an effort to reach a ground. Many tank vessels, and some of the cargo vessels, carrying gasolene and similar explosives are equipped with wireless apparatus, and in some cases vent pipes are led up the mast and have openings in the vicinity of the antennae. Under certain conditions an explosion might result.

It has been determined, from careful measurements, that the sootfall of Pittsburgh is from 595 to 1,950 tons per square mile per year. Statistics of Great Britain show that in the industrial section of Leeds the annual fall is 529 tons; center of London, 426 tons; Glasgow, 820 tons.

RESTORATION OF EXTINCT REPTILES

What did animals, long extinct, look like when alive, is a frequent query to the paleontologist. The proportions of the body can be more or less easily restored. A recognition of the fact that the prominence of projections and rough places upon the bones of the body indicates the size of the muscles attached thereto, enables the student to make the proportions of his model or sketch with considerable precision. But what did the surface of the body look like? Did it have a smooth skin or was this covered with scales, horn, feathers or hair? This query is especially pertinent if the numbers and arrangement of the bones prove the animal to belong to the great reptile family, since among living reptiles variety in this respect is manifold.

Fig. 1. Impression made by the skin of the side of the body of an ancient reptile in the mud forming its final bed. This dinosaur, Stephanosaurus marginatus, lived some five million years ago, during Cretaceous time, in Alberta. From Lambe

A recent paper by Lambe,* the vertebrate paleontologist to the Canadian Geological Survey, shows one of the aids which the rocks bring to the solution of this query. In the ancient rocks of Cretaceous age in Alberta were found not only the bones of a reptilian dinosaur but, upon the surrounding rock, the impress of its skin. When buried in the ancient delta, the soft mud easily received this impress and before the disintegration of the flesh and its covering of skin, the mud had become sufficiently hardened to preserve the dinosaur coat in relief. Similar finds have within recent years revealed the superficial appearance of various extinct reptiles. Only a beginning has, however, been made in this direction. H. W. S.

NEW USE FOR THE BLOWPIPE

The superstructure of the old Jackson Street Bridge over the Chicago River in Chicago was removed in twelve days by cutting apart with blowpipes and swinging the parts onto barges by derrick boats having sixty-foot steel booms. The bridge had a three-stress span, two hundred eighty feet long and fifty-eight feet wide. A new bridge was necessary to give greater width of travel. It required very nice calculation to plan the order of the removal of the different sections of the bridge so that no accidents would happen.

HARDENING SOFT FATS

By introducing hydrogen into soft fats in the presence of nickel or palladium, either in a pulverized form or in aqueous suspension, the oils or fats are hardened and the melting point is raised; thus an oil of the consistency of ordinary cottonseed oil can be converted into a firm, semi-solid fat with many of the properties of lard. This process destroys all coloring matter and odor.

* Lambe, Lawrence M. *The Ottawa Naturalist*, vol. 27, p. 133, 1914.

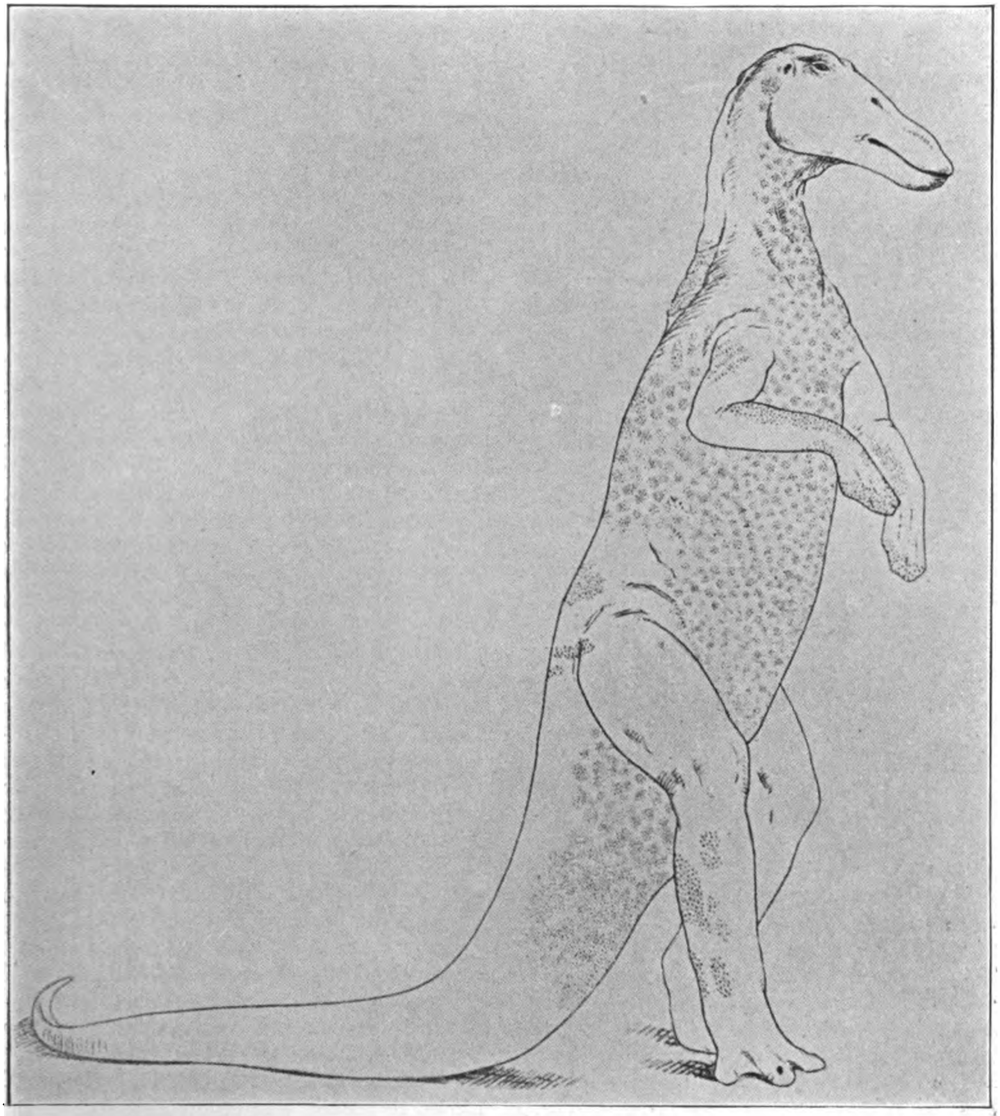


Fig. 2. Restoration of a reptile closely related to the preceding. The surface markings of this dinosaur, Trachodon annectens, are almost entirely known, the parts unknown are left blank. The most complete mold of the epidermal markings of this animal found are from the Cretaceous of Wyoming. From Osborn

BOTTLE-NECK CAVES OF KARST

NEAR Trieste the Guilian Alpine Club has been investigating some very curious caves, which unlike the ordinary ones have vertical sides or even flask-shaped profiles. One at Basiviz is four hundred feet deep and eighty in diameter, and one at Fernetich does not reach the surface, being entered through a "window" in another well. At Opicina there is an underground group of tubes entered through a single mouth. A few have water and are used for wells.

THE TRIPOD OF EVOLUTION

A BIRD'S-EYE view of the plant and animal life which has existed upon this earth from early geologic time to the present, forces clearly to mind the fact that throughout this long procession of organic forms the lowly form has been succeeded by the more highly developed. Nature's coherent plan of action has been the evolution of such adaptive structures that the amount of time needed for the primitive and fundamental concerns of life—self-protection, sustenance and reproduction, has become less and less for each succeeding generation, thus more and more freeing the individual for higher uses of instinct and intelligence. Though the why and how of this evolution is still far from being answered, yet its results are visible in the lines of descent in the plant and animal kingdoms.

The different methods pursued in tracing these lines of descent may be grouped under three heads—comparative anatomy, embryology and paleontology. Of these the first is the oldest and forms the foundation of the other two; it confines its inquiries to a comparison of the forms of living organisms. The second is similarly concerned with the living: it is the study of the development of the individual from the egg or seed to the adult. The study of the developmental stages of any animal or plant reveals much of its ancestral history, since it has been found that, in general, any individual passes, in the course of its development from the egg to maturity, through stages which resemble the adult stages of its successive ancestors in geologic time, that is, the individual history repeats the ancestral. As a division of embryology may also be included the comparatively new science of genetics. Paleontology, deriving its evidence from the remains of organisms no longer living, must make use of the methods of both comparative anatomy and embryology; it must compare the fossil forms both with the living and with each other, and must, whenever possible, study the young of each species. Conspicuous success has, for example, attended the study of the young of the ancient extinct crustaceans—the trilobites and eurypterids.

It is upon this tripod of evidence that is built our modern conception of evolution. To illustrate the method: Comparative anatomy shows that all domestic horses as well as the wild horse, zebra, wild ass and quagga are, except for a few surface characters, such as coloration, tail, mane and size of ears, similar, structure for structure. Embryology shows, amongst other features, that the horse passes through stages in which it possesses more than one toe on each foot, hinting thus at successive ancestors which, as adults, were characterized by five, four and three toes. Paleontology finds fossil remains of those early stages, extending backwards from the present, first into forms but slightly different from the living horses and found in the superficial rocks, through forms with three toes on each foot and short teeth in intermediate rocks, to the small four- to five-toed ancestral horse in the lower rocks. None of these ancestral types have continued to exist to the present.

In the case of the scallop (Pecten), however, one of the earliest ancestral forms has persisted to the present. Comparative anatomy shows that this Pecten is closely related to the living Spondylus. In its embryology, to consider the shell alone, it passes through stages in which (1) there are no ribs; an earlier one (2) in which there are no ears; and a still earlier one (3), with the shell triangular and bearing a row of pits along the hinge margin. Paleontology finds the adult ancestral shells down in the strata of the Paleozoic era corresponding to the embryonic stages of the living scallop, and in succession in the rocks from below upwards corresponding to their appearance in the individual. (It is the form with the character of (3) above, which has persisted

to the present.) It likewise corroborates comparative anatomy in its conclusions by finding connecting links between the living genera.

Thus it is seen that by means of these three kinds of data a fairly complete idea may be gained of the ancestral tree of any individual. Each line of evidenec by itself, is incomplete. The reading of the evolutionary record has been compared to the reading of a book. In comparative anatomy the leaves present the true facts but are arranged in no order, so that one does not know which to read first. In embryology, the leaves, while usually arranged in the proper order, lay too much emphasis on some facts and entirely omit others which are equally important in the ancestral history. In paleontology, however, the pages are in perfect order and present true facts because the actual remains of the ancestors are preserved just as they occurred in succeeding geologic periods. Since, however, only a few cf the total number of individuals that flourished in the past have been preserved as fossils, it must be acknowledged that comparatively few pages of the vast total that make up the complete paleontologic record of past life have been preserved for our reading.

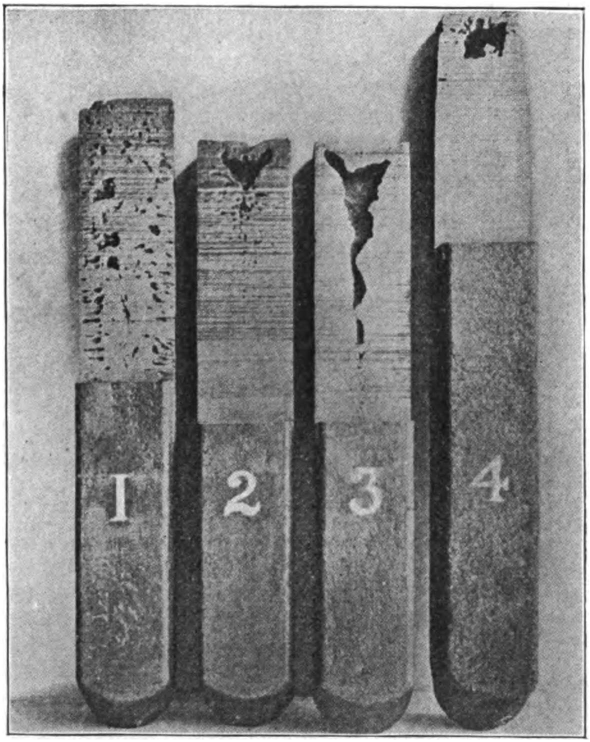
H. W. S.

SOUND STEEL INGOTS

Sir Robert Hadfield, the celebrated English steel manufacturer, has given a great deal of study to the production of perfectly sound steel ingots, and his results have attracted world-wide attention among steel manufacturers and large consumers.

In the illustrations, which we publish by the courtesy of the *Scientific American*, are pictures of four ingots which have been cut through the middle, to show the comparative amount of piping in the specimens. In the case of ingot No. 1, the steel was poured into the mold just as it came from the furnace. Ingot No. 2 shows the same steel as the first, except that it was "quieted" with the addition of .036 per cent. of aluminum. The amount of aluminum was increased to .09 per cent. in the third, and although it is entirely without blow-holes, it is piped deeply at the top, making large waste necessary.

The experimenter next directed his attention to a mold for keeping the upper part of the ingot in a fluid condition



1. Ordinary steel as it comes from the furnace. 2. The same steel with .036 per cent. of aluminum added. 3. Same as No. 1, with .09 per cent. of aluminum. 4. Effected by keeping top of No. 3 very hot while bottom was cooling

while the lower part is solidifying. He accomplished this by placing over the top of the molten metal a thin layer of slag with a bed of burning charcoal above it. The result of this method is shown in ingot No. 4. This, it will be seen, is free from blow-holes, and also from the deep piping which appears in No. 3. The charcoal was kept in a state of violent incandescence by a blast of compressed air.

The aerial consists of a quadrangular closed loop on each car, supported at each corner by insulators on iron pipe attached to the corners of the car. They are raised eighteen inches above the roof of the car

WIRELESS ON RAILROADS

The equipping of a train on the Lackawanna Railroad with wireless telegraph apparatus has excited much general interest. Just what its economic value is cannot be determined on short time trial, nor with a single installation. It has, however, proved of the greatest use in a number of ways. On one occasion the conductor of a train became ill thirty miles east of Scranton, and instead of stopping the train to send a telegram asking for a relief conductor, the wireless operator communicated with the Scranton station and the relief conductor was waiting on the arrival of the train. On other occasions in leaving Hoboken it was discovered that another coach would be needed at Scranton. The car was ordered by wireless and was all ready to be attached to the train upon the arrival at that station. Law breakers have been discovered, and officers were summoned to meet the train at the next stopping place. In addition, of course, commercial telegrams are being sent from this train, and regular toll-rates are being prepared.

Speculation as to the possible usefulness of such installations on railroad trains covers a very broad field. These pertain largely to the running of trains by wireless instead of using the telegraph or telephone. It is obvious that communication can be had with any train anywhere on the road. There are, however, practical objections, which wider experimenting may overcome. The one great problem is that of the aërials; on account of the tunnels and low bridges

over the tracks it is impossible to have high aërials on the train. Now high aërials are necessary if messages are to be sent to great distances; so they were built extremely high at the stations to work with the low aërials on the trains. This makes the transmission of messages between the train and the stations more difficult than sending in the other direction.

We show herewith a cut of the train aërial as it is arranged on the cars, through the courtesy of *The Wireless Age*.

SOME STRANGE FISH OF OCEAN DEPTHS

THE Prince of Monaco, who is primarily an investigating naturalist, has discovered fish with perfectly developed and evidently useful eyes living at a depth of three miles. Light never reaches those depths, for a photographic plate is not affected at one-fifth of that distance below the surface. The explanation seems to be that the fish, whose natural habitat is at the bottom of the ocean, come up at times to some point near the surface where their eyes are useful. In doing so they are obliged to adjust themselves to the difference of pressure, which, at the bottom, approaches twelve hundred pounds to the square inch, and near the surface forty-five pounds to the square inch.

Another extraordinary discovery is that the deep sea fish come near the surface at night, making a vertical migration of ten to twelve thousand feet back and forth presumably every day. A net sunk to the depth of twelve hundred feet will never catch these bottom fish in the daytime, but they can be caught at night with the same net at the same depth. The Prince's conjectural explanation is that the fish have organs for producing the light of phosphorescence, the purpose of which is supposed to be to attract prey. These fish come from the bottom to the surface to seek their food. They rise only at night because the light which lures their prey becomes visible and attractive only in semi-darkness. The suggested explanations of these phenomena are interesting, but may be far from the real truth.

Many queries arise in this connection, as for instance: How can the fish, at that depth, know whether it is day or night? and how can they preserve the use of eyes which practically never see the light of day?

FOOTINGS FOR CONCRETE PILES

A NUMBER of methods have been tried for the purpose of giving the best footing for concrete piles. By one method a tube is driven into the earth, the dirt in the pipe removed, and a moderate amount of cement poured in. By the use of a pile driver, with the weight dropping through the tube, the cement is forcibly spread out at the bottom while in a liquid condition, thus giving a mushroom-like footing, and at the same time making the ground firm. The concrete is then poured into the tube, which is gradually withdrawn as it is filled with the material.

Another method is to drive a steel tube into the earth, remove the earth-core, lower to the bottom a charge of dynamite, with electric connection from above; then fill the tube with concrete. The tube is drawn up a little way, then the charge of dynamite exploded. As the tube is withdrawn the concrete fills up the mushroom-like space at the bottom. The theory is that the pressure of gas liberated by the explosion makes a chamber in the earth as a footing for the pile and packs the earth at the same time. It is contended by some engineers, however, that the use of dynamite shatters the ground and is especially dangerous when in the vicinity of earth cavities and excavations.

A very simple and effective method is sometimes used in Germany which consists of dropping a weight, shaped like a plumb bob, by means of a pile driver. The constant dropping of this weight forces a hole into the ground, the earth about it being packed very hard. The concrete is then simply poured into the hole.

IMPORTANT X-RAY DISCOVERIES

Mr Herbert T. Wade, in the *Scientific American*, gives a description of Dr. Coolidge's recent discoveries in X-ray research. He says that in using the Roentgen ray tubes the penetration of the rays has hitherto been controlled by regulating the vacuum of the tube, and, except for minor details of construction and methods for such regulation of vacuum, there has been little fundamental difference in the tubes used. A new tube, however, designed by Dr. W. D. Coolidge, at the great research laboratories in Schenectady, has recently been developed in which an entirely new principle is involved. This tube gives a pure electron discharge and serves to reduce, in great measure, the actual time of exposure; in fact, it has been considered the most important contribution to Roentgenology since the birth of that science, and it has found an important place in various fields.

Through the courtesy of Dr. Lewis Gregory Cole, professor of Roentgenology at Cornell University Medical College, we were able to examine one of the new tubes which has been used with notable success. Not only is the operator able to adjust it with greater accuracy, but he is assured of stability and exact duplication of results, greater flexibility, a greater output of rays, a longer life of the tube, and the absence of indirect rays developed at various parts of the glass bulb which, of course, affect the sharpness of the impression. The new tubes have a vacuum about 1,000 times as great as the vacuum of the ordinary Roentgen ray tube and make use of a tungsten filament as a cathode, the material out of which, as every one knows, the filament in the ordinary tungsten incandescent lamp is made. This cathode, unlike that in the older type of tube, must be heated in order to render the tube active and capable of being excited. When a current from a storage battery raises the tungsten filament to the required temperature, the electrons are liberated from the cathode by the high potential current ordinarily employed and furnished from an induction coil or transformer.

The penetration of the rays from the tube depends upon the rapidity with which the electrons are thus shot out from the cathode, and this speed is controlled by regulating a low potential current from a storage battery in circuit with the tube, which acts to generate heat in the cathode filament. With one of the new tubes using a filament of twenty-five milliamperes, the stability of the tube will remain permanent for fifty minutes without perceptibly changing the penetration. This gives a Roentgenogram with a uniformity of excellence which has never before been obtained; and after the tube is adjusted to the desired degree of penetration for any given part of the body it may be excited with any desired milliamperage from 1 to 200, for the time required for a correct exposure. Uniform results can be obtained by decreasing the current and increasing the exposure or *vice versa*.

The controlling apparatus is such that an exact duplication can be obtained and, at the same time, the tube is so flexible that it can be operated at a penetration so slight as to show the fine blood vessels of the hand or foot at one instant, while at the next it can be increased so that a penetration far exceeding anything possible with the ordinary tube can be secured, thus making it available for all kinds of Roentgenographic and therapeutic work.

The life of the new tubes is placed by Dr. Coolidge at a minimum of a thousand hours of constant running, so that the tube is more likely to be impaired as the result of accident than from wearing out. The new tube avoids the detrimental effect of the indirect rays generated in the wall of the anterior hemisphere of the tube by secondary or deflected cathode streams which blur the image and give rise to secondary rays in the tissues of the body interposed. To one seeing the

apparatus for the first time the utter absence of fluorescence in the glass is most marked.

With the new tube a scale of length of exposure and current required with different lengths of spark gap has been compiled, which shows exactly what is needed in photographing the various parts of the body. In one instance ten exposures were made in four tenths of a second of actual time. With the stomach, using a spark gap of five inches and a current of 110 milliamperes, the time of 0.06 second was required, while for the detail of the spine, using a current of 30 milliamperes, 15 seconds would be required.

The original tests made in the research laboratory with experimental apparatus on animal tissue and strips of metal were repeated in Dr. Cole's laboratory and a series of test plates were made which showed clearly the differences obtained by varying the conditions in a number of exposures on the same subject.

BACTERIA AT FREEZING TEMPERATURE

S. C. Keith, Jr., of the Massachusetts Institute of Technology, has been making a study of the factors influencing the survival of bacteria at temperatures in the vicinity of the freezing of water. In making his conclusions from the experiments he says that low temperatures alone do not destroy bacteria. On the contrary, they appear to favor bacterial longevity, doubtless by diminishing destructive metabolism. Frozen food materials, such as ice cream, milk and egg substance, favor the existence of bacteria at low temperatures, not because they are foods, but apparently because they furnish physical conditions somehow protective of the bacteria.

It seems likely that water-bearing food materials as well as sugar solutions, glycerin solutions, etc., freeze in such a way that most of the bacteria present are extruded from the water crystals with other non-aqueous matters (including air) and lie in or among these matters without being crushed or otherwise injured; while in more purely watery suspensions, and, above all, in water itself in which the whole mass becomes solidly crystalline, they have no similar refuge but are perhaps caught and ultimately mechanically destroyed between the growing crystals. This theory would explain the absence of live bacteria in clear ice, their comparative abundance in "snow" ice and "bubbly" ice, and also the fact that the more watery food materials, when frozen, contain the fewest, and the least watery, the most living bacteria.

The comparatively rapid death of bacteria in non-nutrient materials at higher temperatures and their slower dying at lower temperatures agrees well with the theory of simple starvation or destructive metabolism. At the higher temperatures they perish quickly because they burn themselves out quickly; at the lower, more slowly, because they consume themselves more slowly. At temperatures where metabolism ceases altogether, they continue to exist in a state of suspended vitality similar to that exhibited by many other and higher plants which in the far north are subjected without apparent injury for long periods to temperatures much below the freezing point of water.

A BIOLOGICAL FORECAST

In a recent article Professor G. H. Parker of Harvard says:—

"If the green plant in sunlight can elaborate from water and carbon dioxide one of our chief food substances, starch, there is no reason why the biological chemist should not discover the secret of this process and imitate it on a commercial scale. Starch, I believe, has never been synthesized, but some sugars have been so constructed. Two years ago Stoklasa and Sdobnicky made the remarkable discovery that by the action of ultraviolet light on nascent hydrogen and carbon dioxide sugar was formed. Such discoveries as this suggest the means by which we are to throw off our slavery to the green plant and I am convinced that in time this overthrow will become so complete that our staple foods will be the products of the biological chemist."

CORROSION OF WROUGHT-IRON

THE resistance of wrought-iron to corrosion is remarkable in spite of any statements to the contrary based on short periods of comparative tests. At Delhi, in India, there is a monumental column of this material which is over one thousand years old. It is stated on good authority that in various humid parts of India native-made iron, whose origin is too far back to be definitely known, is still seen fully exposed to weather conditions. At the Epping church, near London, there are some exposed iron handrails, one hundred and fifty years old, the section of which has not been diminished below the margin of safety during this period. This iron was probably smelted and puddled in small quantities, using charcoal for fuel, from particularly high-grade and easily reduced ore.

PLATINUM DEPOSITS

THE American Consul at Wenden, Westphalia, has made a report of the discovery of platinum at that point in Germany, which yields from 0.9 to 1.9 troy ounces of platinum per cubic yard. This is said to be a higher content than in the Russian deposits. The extent of the deposit is not actually known, but it would appear that the platinum market would be considerably affected by the discovery. Ninety-five per cent. of the present annual production of 13,250 pounds comes from Russia. The demand exceeds the supply, and in twenty-two years the price has advanced from $89 to $488 per troy pound. Nearly one-third of the output is used in electro-technical industries, and another third in dentistry.

A NEW FISH-CURING METHOD

VICE-CONSUL GENERAL EUGENE M. LAMB reports a new method recently introduced into the fisheries of Nova Scotia for preserving fish for shipment.

The fish are dumped into a tank of sea water filtered through willow charcoal to remove noxious gases and foreign substances. Brown sugar is placed in the tank to serve as a germicide for any organisms that may be active at low temperatures. The temperature of the water is then lowered to ten degrees centigrade below zero and 16.1 per cent. salt is added to prevent ice formation. After two hours of this treatment, the fish are ready for shipment to market.

THE marine disasters of 1913 cost Great Britain $35,000,000. The losses on the Great Lakes in the United States are estimated at $4,700,000. The above figures represent only total losses.

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The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

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THE MYSTERY OF MATTER

WHAT IS KNOWN AND WHAT SCIENTISTS CONJECTURE ABOUT THE COMPOSITION OF MATTER, ITS PROPERTIES AND ITS PHYSICAL STRUCTURE

THERE has recently been published by the D. Van Nostrand Company an unusually entertaining treatise on chemistry by Geoffrey Martin, an English scientist. His object was to describe in an attractive way the triumphs and wonders of modern chemistry, and he has succeeded so well that the reading of the book has a peculiar fascination. Our readers will get an idea of the general character of the book from the chapter on "Matter" which follows:

The endless circulation of matter in the universe is, perhaps, one of the most wonderful facts with which chemistry has to deal. It is this endless change which causes the history of the most common and insignificant objects about us to be more astonishing than any fairy tale. What a wonderful story, for example, could be written of the material which forms our bodies! It came into existence in the immense depths of space millions upon millions of years ago, and wandered for ages through darkness and void until it reached our earth. Perhaps it fell upon the earth in a fiery meteorite, or perhaps it merely joined the huge fire mist from which our solid world condensed. Since then it has run round age after age in an endless circle of change. First it formed part of that vast primeval atmosphere which surrounded the globe, and blew in mighty winds around our planet; then it was absorbed into the body of some humble living being, and when this being died and its body decayed, the matter passed into the rich mother earth. Thence it passed into some plant by means of its roots; and from the plant it passed, by the prccess of being devoured, into the body of some animal; and from the animal again it passed to earth and thence to plants and animals again; and so on through an endless cycle of change, coursing through the bodies of innumerable multitudes of living forms, which stretch far back in a dim unending vista into the depths of time. Finally it reached man; yes, the very atoms which thrill and flash in our brains and muscles once formed part of a living plant or animal millions of years ago, and will again form part of a living plant or animal millions of years hence. In some form or other the matter which now forms our bodies will exist long after the whole present order of creation has passed away; indeed, it may well yet blow in the winds of worlds as yet unborn, and thrill in forms of life not yet evolved.

This ceaseless round of matter seems to have impressed Shakespeare, who has caused Hamlet, not pleasantly, to refer to the subject more than once. In Act IV, Scene 3, we have the man eating the fish

that has fed on a worm, which in its turn was sustained upon a dead emperor, and are shown "how a king may go a progress through the guts of a beggar." In Act V, Scene 1, there is the notable speech of Hamlet, when he says,

> Alexander died, Alexander was
> buried, Alexander returneth into dust: the
> dust is earth; of earth we make loam: and
> why of that loam, whereto he was converted,
> might they not stop a beer-barrel?
> Imperious Caesar, dead and turned to clay,
> Might stop a hole to keep the wind away.
> O, that that earth, which kept the world in awe,
> Should patch a wall to expel the winter's flaw!

Not only the material forming our bodies, but every piece of material around us possesses an antiquity so vast as to be almost incredible. What endless convolutions and vicissitudes, for example, has a common lump of earth passed through before it reached its present form? It has been part of continents which have long since vanished, and has borne the tread of races long since extinct. It has been on the top of mountains and at the bottom of oceans; it has often formed part of the molten fire underground, and, in spite of all this, it still remains, and will remain during endless ages yet to come.

All these wonders arise from the fact, brought to light by the patient labors of generations of scientific men, that matter is indestructible, that it can be neither generated nor destroyed by any means in our power. It may pass into a totally different series of forms, but at the end of a whole series of changes the same weight of matter remains as was there at the beginning. For example, when a candle burns away it disappears, and the matter forming it is apparently annihilated; yet this is not really so; for the candle merely burned to invisible gaseous forms of matter, which, when collected and weighed, are found to contain the same weight of carbon and hydrogen (the kinds of matter which make up the candle) as was originally in the candle itself. This latter fact, indeed, can be shown easily by means of a very simple experiment. A candle is fixed in a stoppered bottle which is then weighed. The candle is now lighted by making a platinum wire which encircles the wick, white hot by means of an electric current. The candle burns for a short time and then goes out. On reweighing the bottle when it is cold, no alteration in weight will be found to have occurred, although part of the candle has burned into invisible gas.

In the light of recent discoveries, however, it may be doubted whether matter is absolutely indestructible, but there is no doubt that ordinary matter, if decomposable at all, decomposes so slowly that a single pound of it will endure through millions of millions of centuries, a time longer than that required for the whole solar system to evolve.*

It is indeed hard to conceive that anyone in full possession of his senses can look into the heavens on a dark starry night and remain unmoved. The fact that he looks into a vast void extending upwards for ever and ever, strewn with innumerable myriads of suns and world-systems, must fill even the most brutalized mind with a feeling of awe and bewilderment. Yet the interspace between world and world is not truly empty in the popular sense; for it is filled with a wonderful medium, termed the *ether*, which fills all the depths of space, and bears through it to us, in the form of minute ripples or quiverings, the light of the distant stars. Matter moves through this vast sea of ether, apparently without resistance, much as a sieve moves through water, or a wind rushes through the trees; but what "matter" is, we do not know. All that we do know is that it is totally unlike anything which our crude senses conceive it to be, and is probably far more wonderful than anything we can even imagine.

We know that the solid objects about us are not really solid and impenetrable. They consist of countless millions of tiny particles, tiny atoms as chemists call them, in unceasing and swift motion. A single grain of lycopodium powder is made up of over a trillion of such atoms; earth, the paper on which I write, the very

* Sir Oliver Lodge, "Modern Views of Matter" (1903), p. 25.

air we breathe, consists of unimaginable millions of these tiny worlds, rushing and revolving rapidly as rifle bullets. Mendeleef likens the atoms to the heavenly bodies, the stars, sun, planets, satellites, and comets, and he considers that the building up of molecules from atoms, and of substances from molecules, resembles the building up of systems, such as the solar system, or of twin stars, from these individual bodies.

Even these atoms which build up ordinary matter are by no means solid masses. Far from it. Each atom is probably composed of a few thousands of tiny specks of negatively electrified particles, which fly about in astronomical orbits inside the atoms (much as a swarm of bees would fly about inside the dome of a great cathedral), forming a kind of cosmic system under their strong mutual forces, and occupying the otherwise empty region of space which we call the atom.

The porosity of matter as thus constituted is extreme, and this explains why it can move through the ether without apparent resistance. Matter hangs in space like a faint cloud, and is perhaps a mere misty modification of the wonderful space-filling fluid. Indeed, there is reason to believe that the one massive constituent of the universe is this invisible ether, and that our matter is a mere gauzy cob-web, a mist, or a milky-way floating in it. The reason why matter appeals to us so strongly and clearly is because our bodies are composed of it, and because our sense organs have been evolved to respond to its various motions.*

"Matter," says Francis Galton,† "is a microcosm of innumerable and, it may be, immaterial motes, and . . . the apparent vacancy of space is a plenum of ether that vibrates throughout like a solid." Nor must we forget that matter, as we know it, is but a collection of sensations generated in our brain by an exciting cause; the matter itself which lies behind and gives rise to these sensations remains forever unknowable, hidden behind the veil of changing phenomena. It is none the less real for all that, but still the fundamental fact remains that of the outer world we know nothing except our sensations. A landscape is nothing but a cluster of sensations. So also is a beautiful woman, a lovely flower, a child, a book. Between us and external reality stands an impenetrable intermediary, our nervous system. When we attempt to understand the inmost nature of the outer world, we stand before it as before utter darkness. Outside of ourselves there exists in Nature neither sound nor silence, brightness nor darkness, neither color, odor, space, force, nor anything that we know as sensation. The multitudinous sounds of Nature, the creaking of carts, the cries of animals, the wail of music, the awful roll of thunder are all produced by the excitement of our acoustic nerves, and exist only in our brains. As to the excitement itself, there is nothing to indicate that it is sonorous. It is in our brain that noise is produced; outside of it reigns eternal silence, or worse, since silence is the correlation of noise. Similarly, light is produced by the excitement of the optic nerve, and shines only in our brains; the ethereal vibrations themselves are not luminous. Outside us, then, is utter darkness; the flashing lights and colors of the outer world which incessantly assail us, the sudden glare of lightning, the gleam of gold and scarlet, the green of trees and fields, all the visible glories of the outer world, exist but in our brain. The same is true of all our other senses, and affects to an unknowable degree our conceptions of matter. We are utterly walled in by our nervous system.

We will now give a brief account of the views of the foremost modern thinkers upon the constitution of matter. A wonderful theory of Professor Osborne Reynolds ‡ assumes that the ultimate particles which make up matter are nothing but

* Sir Oliver Lodge, "The Structure of the Atom," *Journal of the Society of Chemical Industry* (1908), Vol. 27, p. 731.

† *The Times*, May 31, 1910.

‡ "The Sub-Mechanics of the Universe," Cambridge University Press, 1903.

empty cracks flitting to and fro like silent ghosts through the vast stagnant sea of ether. The ether is supposed to consist of an arrangement of indefinite extent of uniform spherical grains, generally so close that the grains cannot change their neighbors, although continually in relative motion with each other. The grains are extremely minute, the diameters being 5.534×10^{-18} centimeters (1 inch is 2.5 cms.). The millionth part of an inch could contain half a billion such particles packed side by side. The pressure in the medium is about 10,000 tons per square centimeter. In spaces in which there occur a smaller number of grains than is necessary to render the piling "normal," such local deficiencies are permanent. They can run through the medium without the medium moving with them, much as waves pass over water without a transfer of matter. They attract each other according to the laws of gravitation, and constitute the particles of matter. Hence, in contradistinction to our usual notions, matter consists of merely cracks or gaps of space; it is "emptiness," and not "fullness," as one would naturally suppose.

The theory gives a complete explanation of gravitation, the velocity of light, and numerous other physical phenomena.

According to another theory, matter is an electrical manifestation. It consists in aggregations of electrical particles, called by some authors, "electrons," by others, "corpuscles." The diameter of these particles has been calculated to be only 0.961×10^{-13} centimeters;* so that over 20,000,000 could be packed side by side in the millionth of an inch.

All the different elementary chemical atoms are made up of aggregations of many thousands of these minute bodies; these electrons or corpuscles, therefore, correspond to the long-sought primary matter or "protyle," out of which all the chemical elements are built up.

According to Larmor, the electrons are nothing but centers of strain, probably minute eddies, in the ether. These strain centers must not be thought of as part of the medium forever separated from the rest, for it is the strain alone which persists, the part of the ether which is affected by it constantly changing as the sub-atom is moved.

In Whetham's words,† "Matter is a persistent strain form flitting through a universal sea of ether, and ether, in its turn, is a close-packed conglomerate of minute grains in continual oscillation. . . . But what of the grains of which the ether is composed?

"Are they 'strong in solid singleness' like the one-time atom of Lucretius? Or have they parts within which opens a new field of complexity? Of what substance are they made?

"Has a new ether more subtle than the first to be invoked to explain their properties, and a third ether to explain the second? The mind refuses to rest content at any step of the process. An ultimate explanation of the simplest fact remains, apparently for ever, unattainable."

If matter is but a number of minute whirlpools in a universal sea of ether, surely by the slow diminution of their velocities in the course of ages these whirlpools must ultimately die out, again passing into the ether? The idea of the slow passage of matter into ether has been put forward by many recent writers, amongst whom may be mentioned Le Bon.‡ According to such a view, the material universe must be slowly disappearing. So that even the stately world-systems of space are smitten with a process of slow decay; even as the planets circle in silence around their central suns, they are rushing into oblivion, and ultimately must vanish, like clouds in a summer's sky, leaving no wrack behind them to show that they have been and gone. We have, however, no experimental proof of this view.

The most fundamental property of matter for dynamical science is *mass.*

* Arrhenius "Theories of Chemistry" (London), 1907, p. 91.

† "Recent Advances in Physical Science" (1904), pp. 282-294 (Murray).

‡ "The Evolution of Matter," by Dr. Gustave Le Bon (London), 1907. (Kegan Paul, Trench, Trübner & Co.)

The mass of the body used to be defined as a measure of the quantity of matter it contained. It is explained by the electronic theory of matter as an effect of electricity in motion. If this is so, it can be shown that the mass of a body must increase with its velocity, and, indeed, actual experiments by Kaufmann showed that this is the case. According to this idea, the mass of a body is not invariable, but rapidly increases as its speed approaches that of light (3×10^{-10} cms. per second, or 186,000 miles per second), and were it actually to attain this speed, its mass would be infinite. It follows, therefore, that the velocity of no material body can exceed that of light. But if the velocity is less than the tenth part of this, the difference in mass from that at very low velocities is insignificant—below 1 per cent. As a matter of fact (excluding certain Cathode and Beta rays), matter is never observed with such high velocities. Even when planets crash together in space and flash instantly into vast masses of glowing rushing gas heated to a temperature almost inconceivable to us, the flying masses of ejected matter never attain velocities approaching that of light. Thus the eruptions in the new star of Perseus, in 1901, the result of some tremendous cosmical collision, did not attain a velocity greater than 466 miles per second. The greatest observed velocity of the huge flames on the sun is 528 miles a second—a velocity exceeding that of a rifle bullet nearly a thousand times. Tremendous as these velocities seem, they are barely the four-hundredth part of the speed of light, so that the deviation from the law of constancy of mass must, even in these extreme cases, have been insignificant.

The amount of matter in the universe is so great as to defy all comprehension. Our earth alone is a huge globe nearly 8,000 miles in diameter, weighing nearly 5.5 times as much as an equal bulk of water. The sun exceeds the earth nearly 300,000 times as regards mass; and there exist at least 100,000,000 suns visible in a large telescope, some of which are larger, some smaller, than our own sun. In addition to these visible suns there is, perhaps, an even larger number of dark suns, bodies whose existence is only revealed to us when they come into collision with other bodies and produce the new stars which, from time to time, suddenly blaze in the sky.

Now, even the smallest grain of dust visible to the eye contains nearly a billion atoms of matter. How many atoms then, occur in the whole giant bulk of the earth? How many in the whole universe? If a grain of dust is a wonder heap, a structure infinite in its complexity, what shall we say about the universe?

The whole of this tremendous bulk of matter does not consist of the same stuff throughout. Chemists have shown that there exist some eighty or ninety distinct kinds of matter termed elements. Everything we see about us on the earth is built up of atoms of these different elements, and the spectroscope tells us that the same 80–90 elements also build up the world-systems of space.

A LENSLESS STEREOSCOPE

THE lensless stereoscope is announced from Zurich, a device which will produce the effects without the familiar and customary apparatus. It is the product of Dr. W. R. Hess of the University of Zurich, and from the early reports he seems to have made practicable the principle involved when one interposes the finger between the eyes and a stereoscopic picture. Screens are so placed as to cause each eye to view only the picture belonging to it and the combination of them in the two eyes produces the stereoscopic effect. The application of the device, according to Dr. Hess, is particularly for the motion pictures in which the figures will have not only the familiar movements, but will be figures in actual relief. With the addition of color, there will be possible a veritable revolution in graphic presentation.

THE Hoosac tunnel, which is four and three quarters miles long, is to be exceeded in length by the Roger Pass tunnel through the Rocky Mountains which will extend five miles and cost $10,000,000.

THE ORIGIN OF THE ROCKY MOUNTAINS*

STORY OF THE CREATION OF THIS GREAT MOUNTAIN SYSTEM AS DECIPHERED FROM THE DOCUMENTARY EVIDENCE OF THE STRATA THEMSELVES

BY S. J. SCHOFIELD

INTRODUCTION

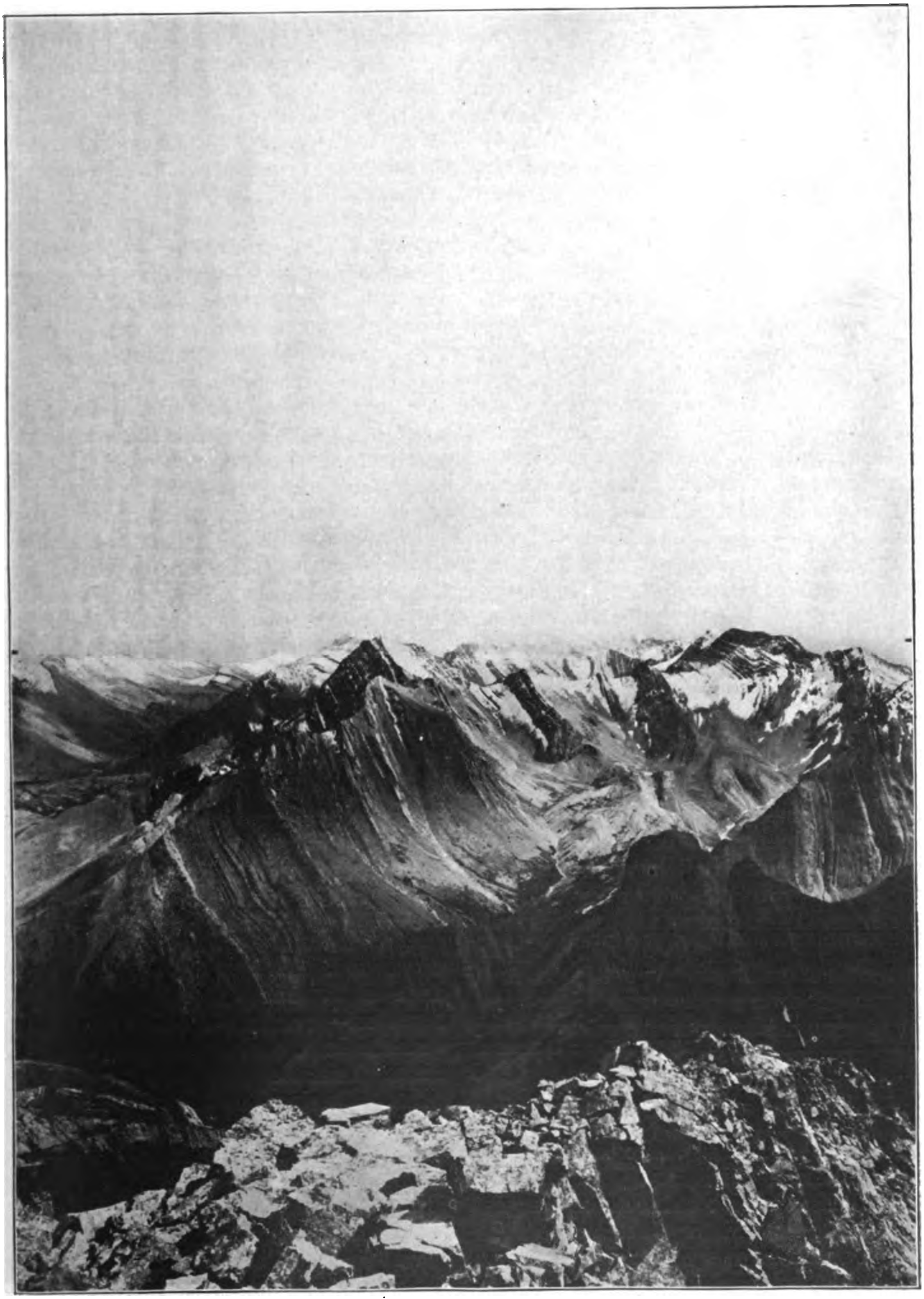
THE elevated and mountainous tract which borders the western portion of North America is made up of a number of parallel mountain systems, which trend northwest and southeast and hence parallel in a general way the corresponding Pacific coast line. This tract, known as the North American Cordillera, has a width of four hundred miles in southern British Columbia.

In an endeavor to describe the origin of the Rocky Mountains it may be well to precede the discussion by a general analysis of the North American Cordillera in Canada. This has been admirably done by Professor R. A. Daly whose monumental work on the geology of these mountains has just been published. The basis for the classification of the Cordillera is the great topographic or geographic breaks which cut it up into distinct mountain systems. These geographic breaks are expressed in the form of longitudinal valleys which are remarkable features of the Cordillera and, as far as present knowledge goes, they coincide with the great structural breaks on which a genetic classification of mountains should be based.

On approaching the Cordillera from the east the first range of the Rocky Mountain system rises from the monotonous plains in a long, abrupt line of serrated peaks, flanked at the base by a low range of foothills. This system extends from Montana to the Arctic Ocean, in the form of an elongated chain composed of three major segments, arranged in echelon, in which each successive northern segment is, as it were, stepped to the west. Each segment is composed essentially of a remarkable system of parallel ridges, whose strike corresponds to the general trend of the main range. The average width of the Rocky Mountain system in southern British Columbia and Alberta is about sixty miles, while at the Liard River it apparently loses its regularity and importance, only to again assume the same character farther north. In British Columbia and Alberta many peaks exceed 10,000 feet, while the average elevation ranges between 8,000 and 9,000 feet.

On the west of the Rocky Mountain system occurs the Great Rocky Mountain trench, a continuous geographic break, recognized from Montana as far north as Alaska, crossing the international boundary line in the vicinity of Dawson. In the southern part of the Cordillera in Canada, the Purcell Range—an elliptical-shaped mass of rugged mountains, occurs west of the Rocky Mountain trench. Separating the Purcell system on the east, from the Selkirk Range on the west, is the Purcell trench in which occur Kootenay River and Kootenay Lake. West of the Selkirk Range and separated from it by the Selkirk valley, comes the Columbia system. The last three systems, the Purcell, Selkirk and Columbia, trend very close to north and south, and hence are terminated to the north by the Rocky Mountain system which, trending northwest-southeast, cuts them off. The Columbia Range gradually passes into the Interior Plateaus, characterized by low rounded hills and plateau-like upland stretches, having a mean elevation of 3,800 feet above sea level. This is succeeded to the west by the Coast Range which parallels the Pacific coast,

* Published by permission of the Geological Survey of Canada.



Rocky Mountains—Note the folding of the rocks

hence trending in a northwest-southeast direction. The descent into the Pacific is precipitous and many deep fiords mark its contact. The most westerly subdivision of the Cordillera is the Vancouver Range constituted by Vancouver Island and the Queen Charlotte Islands, recently described by J. D. Mackenzie in this magazine. The southern extension of this island festoon is the Olympic range of Oregon.

DISTRIBUTION OF ROCKS

For the purpose of description the Canadian Cordillera can be grouped into two basins of sedimentation: a Pacific basin extending from the Columbia system to the Pacific Ocean; and an Eastern basin covering the area from the Columbia system to and including part of the Great Plains. These basins geologically can be considered as units in a genetic sense.

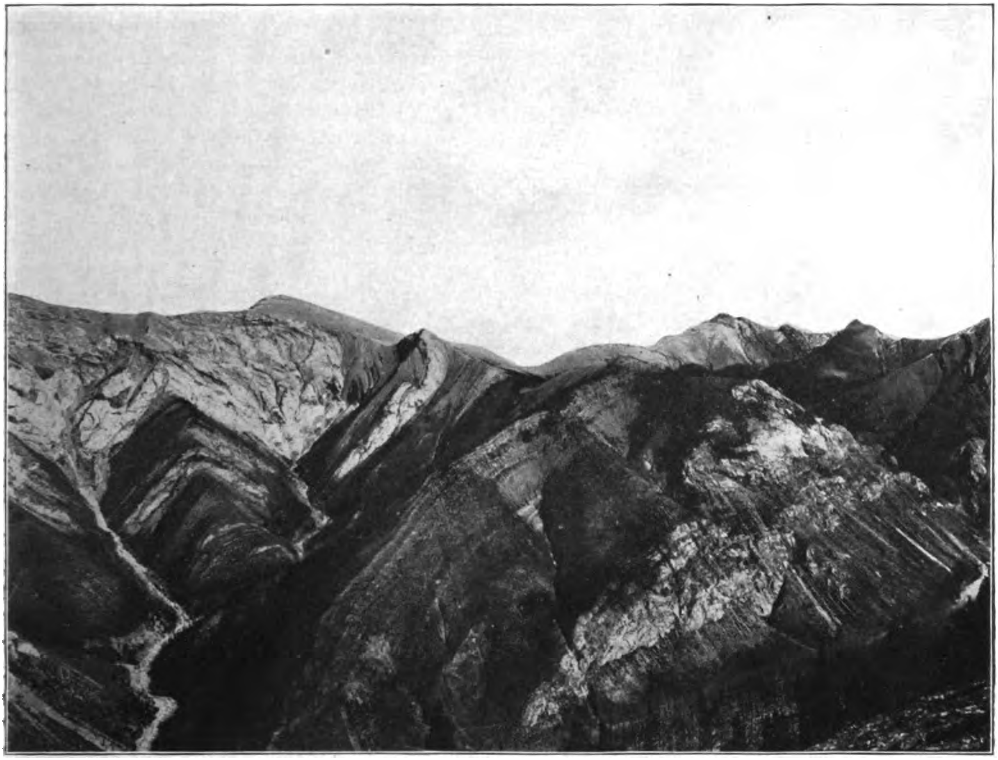
The Columbia range consists in great part of ancient gneisses and schists, the oldest rocks in the Cordillera. These rocks formed at one time the old land mass which extended in a northwest-southeast direction from Central America to the Arctic Ocean. The greater part of this old land is buried under recent deposits or has been destroyed by the invasion of vast quantities of molten rock. The majority of these gneisses and schists are of sedimentary or waterlain origin and hence must have been derived from a still more ancient land now unknown and shrouded in mystery. To the east and west of this old land lay basins in which sediments derived from it by agents of degradation accumulated in vast quantities, for the most part, on an ocean floor.

The Eastern basin, or geosynclinal, which forms the subject of this article, includes the area now occupied by the Selkirk, Purcell and Rocky Mountain systems. The Selkirk and Purcell ranges, with a geological history similar to that of the Columbia range, consist in great part of bedded rocks of Pre-Cambrian age, intruded by masses of igneous rocks of the granite family. The Rocky Mountain system, the youngest member of the Cordillera, is composed almost entirely of bedded rocks ranging from early Palaeozoic to late Cretaceous, while the Great Plains are underlain at the surface by deposits of Cretaceous and of Tertiary age.

Deposits of the last geological epoch, the Pleistocene, or Glacial period, are scattered sporadically over the entire Cordillera.

BUILDING OF THE PURCELLS

If we could stand on the ancient land in the neighborhood of the Columbia range in Pre-Cambrian time, to the west could be seen a rolling and monotonous landscape of moderate relief, while to the east, as far as eye could see, a shallow sea in which was being deposited sand and mud derived from the gradual wearing away of the old land by atmospheric agencies and by running water. That this sea was shallow and remained shallow till Cambrian time is evidenced by the ripple marks, mud cracks, rill marks, and the casts of salt crystals now preserved in these hardened muds. At the dawn of the Cambrian period this ancient sea became greatly enlarged, and mingled its waters with those of the ocean. This mingling permitted the life which inhabited the ocean to invade the shallow continental sea, for it is in these deposits that we find for the first time definite fossil remains in the form of trilobites, brachiopods and marine worms. After this period the waters in the sea gradually deepened and marine invertebrate life abounded. This is shown by the presence of limestones containing abundant remains:—brachiopods, corals, and lamellibranchs in the Devonian and Carboniferous formations of the Rocky Mountains. During Jurassic time, represented by the deposition of marine, carbonaceous muds, the first forecasts of a great mountain building period were registered. During the latter part of the Jurassic, or early Cretaceous, the Purcell Mountains were built. They consist of immense folds of stratified rocks forming typically folded mountains strongly resembling the Juras of Europe and the Appalachians of the Eastern United States. The area



Rocky Mountains

affected by this folding is represented on our modern maps as constituting the land as far east as the Kootenay-Columbia valley or Rocky Mountain trench. It was in the neighborhood of this trench that the western shore line of the continental sea stood after the Jurassic Revolution. It had been shifted from the Columbia range as far east as the western part of what is now represented by the Rocky Mountains.

THE ORIGIN OF THE ROCKY MOUNTAIN SYSTEM

After the building of the Jurassic or early Cretaceous mountains, they were at once subject to destruction by the agencies of erosion. The results of this erosion can be seen in the Cretaceous strata of the Rocky Mountain system. From a study of these strata, which for the most part are composed of conglomerates (water-worn pebbles) and carbonaceous shales (hardened muds) with which are associated many seams of coal and impressions of fossil plants, it may be concluded that at certain times the Cretaceous sea was shallow enough to have a dense jungle growth thrive upon its vast deltas formed from the material derived from the destruction of the Jurassic mountain ranges (Purcell and Selkirk) to the west. Sedimentation continued throughout the Cretaceous until sufficient stress had accumulated locally in this part of the earth's crust for the generation of another great mountain system, the Rocky Mountain system proper. For the formation of this great thickness of Cretaceous strata, the Purcell and Selkirk Ranges were worn down to a low rolling landscape over which the meandering streams wandered sluggishly. This landscape, in technical language, is called a

peneplain, and since it was formed during Cretaceous time, a Cretaceous peneplain.

At the close of the Cretaceous or in early Tertiary, the Rocky Mountains were formed. The earth's crust in this region was raised first in a series of gigantic folds with their longer axes trending northwest-southeast or parallel to the Pacific coast. In the eastern part of the range blocks of the crust were pushed up and carried bodily over the surface for a distance, in the case of the most eastern blocks seen east of Banff, of eight miles. Thus the Rocky Mountain system is a series of parallel ridges with steep faces to the east and gentle slopes to the west, and, in a view from one of the higher peaks, strongly resembles the parallel waves of the sea as they approach the shore. This simile is made more striking by the presence of the snow and ice on the northeastern slopes of the peaks in strong contrast to the deep green coloration of the forest covered valleys. In the picture the snow and ice sparkling in the sun represents the foam on the waves and the green forest, the cool depths of the ocean.

SCULPTURING OF THE VALLEYS

The initiation of a mountain chain by the folding of any portion of the earth's crust marks the beginning of its destruction. Rain descending on this elevated portion collects into streams which rapidly, in a young mountain ridge, gnaws for itself a valley in the folded strata. This first ridge probably will form the axis of the range. The next ridge which rises will be the scene of a battle of giants seeking supremacy. The outgoing stream endeavors to maintain its course to the sea across the rising ridge which offers a barrier to its progress. From an examination of the transverse streams of the Rocky Mountains we see the victory invariably rested with the streams which now cut through the folds and fault blocks. These through-going valleys, making it possible for the transcontinental trains to reach the Pacific, have become the highways of commerce and travel. Such valleys are occupied by the Crowsnest Branch and the main lines of the Canadian Pacific and the Grand Trunk Pacific Railways.

These streams are termed antecedent streams since they kept their course in spite of the barriers raised (by the mountain uplift) against their progress. The longitudinal streams, on the other hand, occupy weak portions of the mountain area. In the Rocky Mountains they occur in areas of Cretaceous rocks which, being composed of soft shales, sandstones and conglomerates, are more easily eroded than the Devono-Carboniferous limestone on either side. These streams, called subsequent streams, since they are initiated subsequent to the mountain building, are tributary to the through-going or antecedent streams. The position of the valleys in the Rocky Mountains, in contrast to that of the Purcell Range to the west, depends entirely upon the structure of the mountains, that is, the drainage is impressed concordant with the folding and faulting of the underlying bedded rocks and hence the valleys belong to one cycle of erosion. In contrast to this, the drainage of Purcell Range is entirely independent of structure and its history can be referred to two cycles. In the first, during Cretaceous time, it was worn down to a peneplain, then uplifted concomitantly with the formation of the Rocky Mountain system. This uplift rejuvenated the streams, which again eroded out the present valleys which can be referred to the second or Tertiary cycle of erosion.

SCULPTURING OF THE ROCKY MOUNTAINS BY GLACIERS

The final moulding of the Rocky Mountains into their present form is due to the erosive action of ice. An examination of any area within these mountains would show that the heads of nearly all the streams terminate in a beautiful lake or tarn nestling in a rock basin. The basins are called cirques and owe their origin to the work of snow and ice. The configuration of this mountain tract previous to the Glacial period was naturally marked by inequalities in the upland stretches and in these inequalities snow would collect which, on the arrival of the

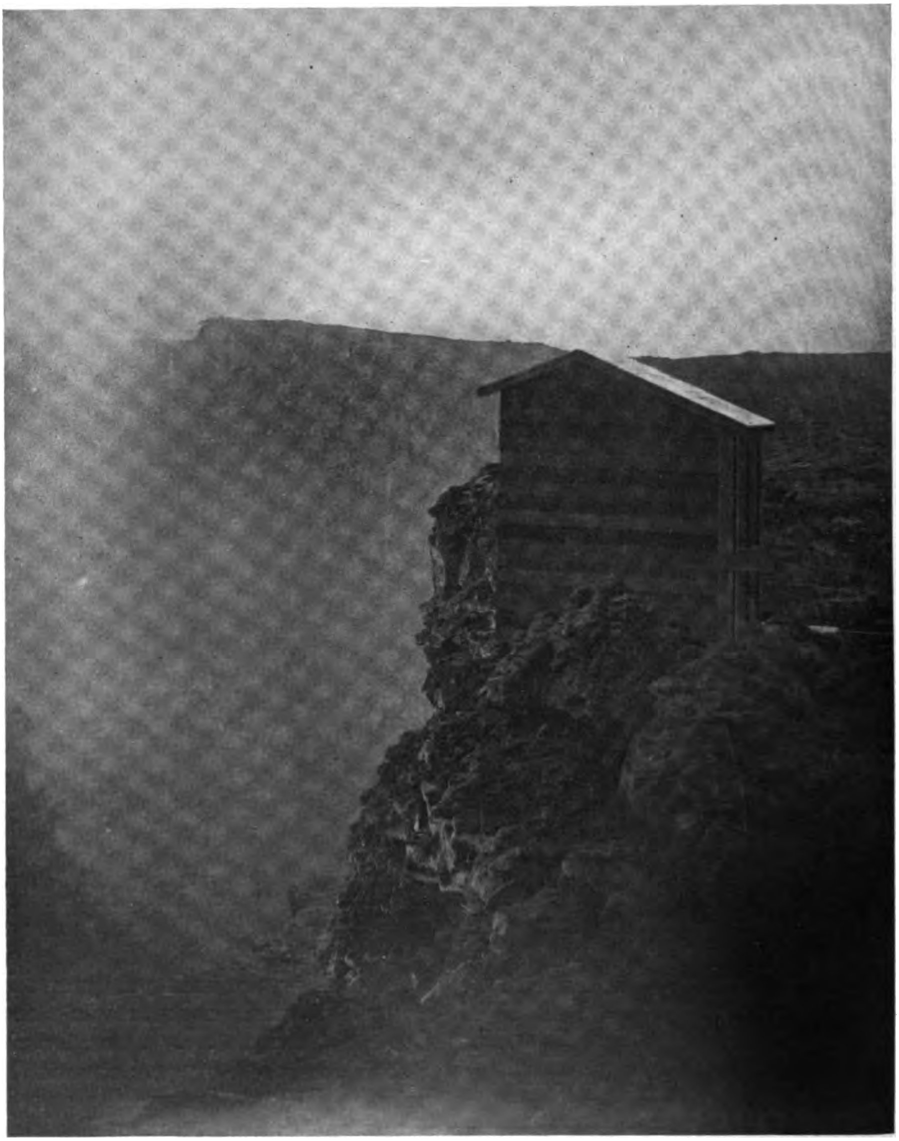
Rocky Mountains looking south—Note the steep eastern slopes and the gentle western slopes

glacial period, would not completely melt during the summer months and would continue to collect until, with the precipitation in the winter far exceeding evaporation in the summer, the collection of ice would slowly move down the slopes into the valleys. The inequalities which would be filled with snow would gradually enlarge by the movement of the water underneath the snow and even by the snow itself as it crept slowly down the slope. With increasing diameter these depressions would be occupied first by a permanent snowfield and finally by the névé of a glacier. Plucking action along the bergschrund would now rapidly push erosion headwards. This action is well described by D. W. Johnson * who descended 150 feet into a bergschrund in a glacier in the Sierra Nevada. "It was in all stages of displacement and dislodgement, some blocks having fallen to the bottom, others bridging the narrow chasm and others frozen in the névé. Clear ice had formed in the fissures of the cliff, it hung down in great stalactites, had accumulated in stalagmitic masses on the floor." Here he states that for a considerable part of the year there would be "a daily alternation of freezing and thawing. Thus a cliff would be rapidly undermined and carried back into the mountain slope, so that before long the glacier would nestle in the shelter of its own making. The ice grips like forceps any loose or projecting fragment in its rocky bed, wrenches it from its place and carries it away. . . . as the cirques receded, only a narrow neck would be left between them, which would ultimately be cut down into a gap or col. Thus a region

* D. W. Johnson, *Science*, new series, Vol. 9, 1899, p. 106.

of deep valleys, with precipitous sides and heads, of sharp ridges and of more or less isolated peaks, is substituted for a rather monotonous, if lofty, highland."

From the above description it can be seen that the detailed beauty of the Rocky Mountain system with its castellated crags, horns, cols, aretes, and cirques, is not due to the forms originating with the building of the mountain ranges: this merely places the foundation for the subsequent superstructure which is created in its main outlines by the erosion of running water, while the final decorations are furnished by the artistic touch of snow and moving ice.



Instrument House, Halemaumau, April, 1912, looking west. Photo., E. Moses

THE DIARY OF KILAUEA

AN IMPORTANT contribution to scientific knowledge is that just published by the Society of Arts. The Institute has recognized the need of systematic observation of volcanoes and for the purpose has established in the Hawaiian Islands an observatory, where, with most recent methods and equipment, the facts that the crater has to offer are to be collected. The work owes its initiative to the interest and activity of Professor T. A. Jaggar, Jr., of the Geological Department, who is the for the purpose of making investigations at the volcano of Kilauea, where the station is located.

The Institute has the lease of a tract of three acres on the brink of the crater, with the option of renewal, and its station includes living rooms, administration offices and work rooms, while the Whitney Laboratory of Seismology is a basement room of concrete, floored on the solid ledge of basalt. The place of the instrument house is most striking,

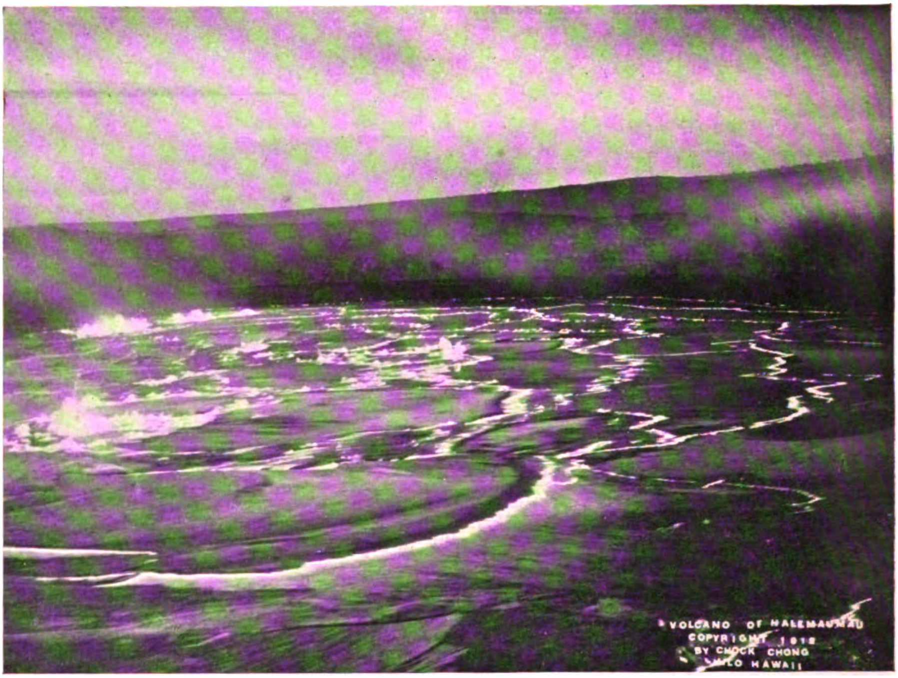
Hawaiian Volcano Observatory, April, 1912, looking north. Photo., E. Moses

director of the Hawaiian Volcano Observatory.

The report of the Hawaiian Volcano Observatory is a neat quarto of seventy-five pages, well illustrated, which gives the history of the institution and its work up to and including 1912.

In 1912 the observatory was put on a five-year foundation, and early in the year the present building was constructed. Dr. Jaggar was named head of the observatory and relieved of his duties in Boston being on the very edge of the rim, where at times the clouds from the crater encompass it. During some of the experiments it has been necessary to establish a line of assistants who by calls from one to another directed the manipulation of the instruments.

The story given in the report is largely a day by day account, and valuable for scientific purposes. The conduct of the fiery lakes in the bottom of the crater is chronicled, the oscillations of the lakes



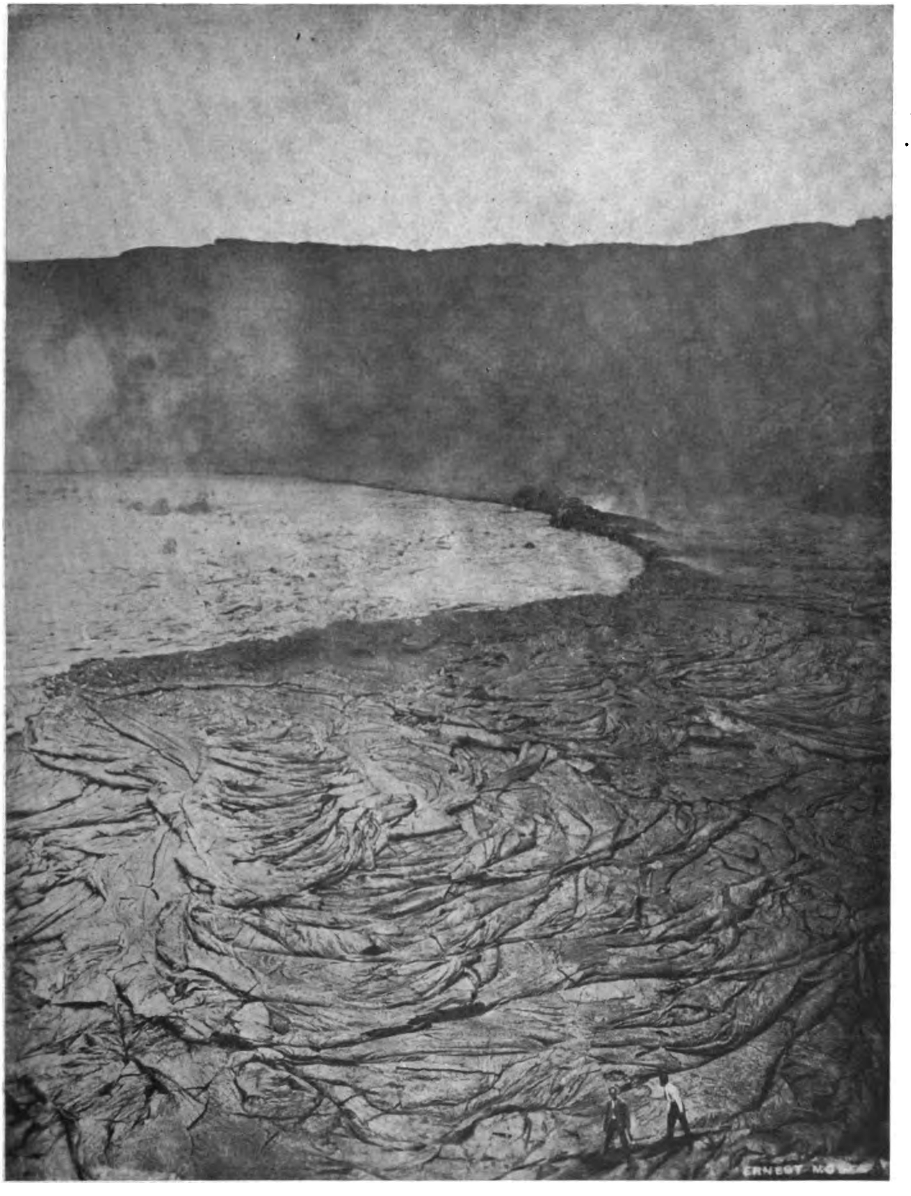
Halemaumau, about January 4, 1912, looking west. Photo., Chock Chong

within their basins, the different kinds of action, the fountains, one of which, "old faithful" was playing at intervals of thirty seconds, sending fiery spray to one hundred feet in height, while the earthquake shocks of every little while are noted.

Experiments were made in gas-composition of the vapor clouds above the lakes, the flows of molten lava into fiery pools were described and the floating island. New cones on the floor of the great crater were a phenomenon of interest, the fall of the crater walls, the range of the fire with reference to surface, were features in an activity that knows no cessation.

Part of the work was that of Perret and Shepard, the former the well-known vulcanologist and the latter detailed for the work by the Carnegie Institution. In this series of observations, a cable was stretched across the lake and from it the thermometers were lowered into the lava to ascertain its temperature. It was a very difficult performance, and one after another of the instruments were lost, on account of the heat and acid condition of the vapors, which melted or corroded the wire ropes. One record was obtained, however, at 1800° Fahrenheit, and the moment after the wire ropes were melted and the instrument lost. It was the third pyrometer thus to be destroyed, but the observation is considered to be a good one of the temperature of Kilauea lava.

One of the striking matters presented by this volume is a bit of prophecy. Dr. Jaggar thinks that there is a rhythmic escape of lava, which has been fairly well verified by the records of past eruptions. Mauna Loa, which is the subject of this prediction, seems to have decreased the duration of its eruptive periods, which previous to 1868 were eleven and one-half years long, and since that date have been five years long. The time between these periods when the volcano has remained quiet has decreased from five and one-half years to four and three-quarters. Applying these figures to the last eruption, Dr. Jaggar is looking for renewed



Halemaumau, September 19, 1909, looking southwest, showing traveling fountains, spatter rampart, and flows. Note men in foreground. Photo., E. Moses

activity in this volcano in February, 1915. There is really no satisfactory information on which to predict the month, but from the usual conduct of the volcano, February seems the most probable. It will be of great interest to know whether this prediction, made in September, 1912, is fully realized.

THE STABILITY OF LIFEBOATS

RESULTS OF INVESTIGATIONS MADE TO DETERMINE THE EFFICIENCY OF SOME OF THE MORE COMMON TYPES OF LIFEBOATS IN GENERAL USE

BY H. A. EVERETT

THE following presents the results of an investigation undertaken the past summer to determine the stability of several types of lifeboats in common use on ocean-going ships of these parts. The boats were all stock boats, new, and ready for immediate service.

In its essence, the work consisted of the customary calculations for the curves of statical stability after having made inclining experiments upon each boat to determine the location of the center of gravity. There were four boats and each was inclined in two conditions (1) light with but the apparatus and the two observers on board, and (2) loaded, with the number of persons which the Rules and Regulations of the United States Board of Supervising Inspectors permit. The work provided theses for two members of the graduating class of the Massachusetts Institute of Technology, A. H. Pitz and C. S. Hsin, and was under the immediate supervision of the author.

Four boats were used; the principal dimensions are given in this table, and the lines are given on Plates 1 and 2.

Those of figures 1, 2, 3, 4 were of the standard type of open boat provided with tanks as shown on Plate 2 and were of practically the same external form. Construction plans of the steel one are shown on Plate 2. Both conform to the U. S. rules with air-tank capacities of 51.8 and 76.4 for the wood and metallic boats, respectively.

Figures 5 and 5a show a boat of radically different form which falls within the class commonly called decked lifeboats, as the passengers are carried above a second water-tight skin or deck. It was built of metal (No. 14 B. W. G. galvanized iron) in accordance with the construction plans on Plate 2, and the lower space serves at all times as an hermetically sealed buoyant chamber.

On Plate 1 (lower) is shown a collapsible boat which consists essentially of a flat pontoon of wooden construction pointed at each end, and provided with wooden thwarts, rail and canvas bulwarks. These all fold down onto the upper deck or can quickly be raised and clamped into position when the boat is to be used. A con-

PRINCIPAL DIMENSIONS

Number	Type	Material	Length	Breadth	Depth	Capacity by U. S. Rules	*Weight, Light	Weight carried when tested	Corresponding Number of Persons	Load Displacement
1	Standard	Metal	28′	8′ 4″	3′ 7″	50 Persons	3584	7639	51	10559
2	Standard	Wood	28′	8′ 4″	3′ 7″	50 Persons	2740	7854	52	9784
3	Decked	Metal	28′	9′ 4″	2′ 7″	60 Persons	5392	9962	66	14462
4	Collapsible	Wood	29′ Top 28′ Bot.	9′ 0″	3′ 0″	54 Persons	† 3267 8840	2380	16	12720

* Incl. Exptl. App. and 2 Men.
† Before and after launching.

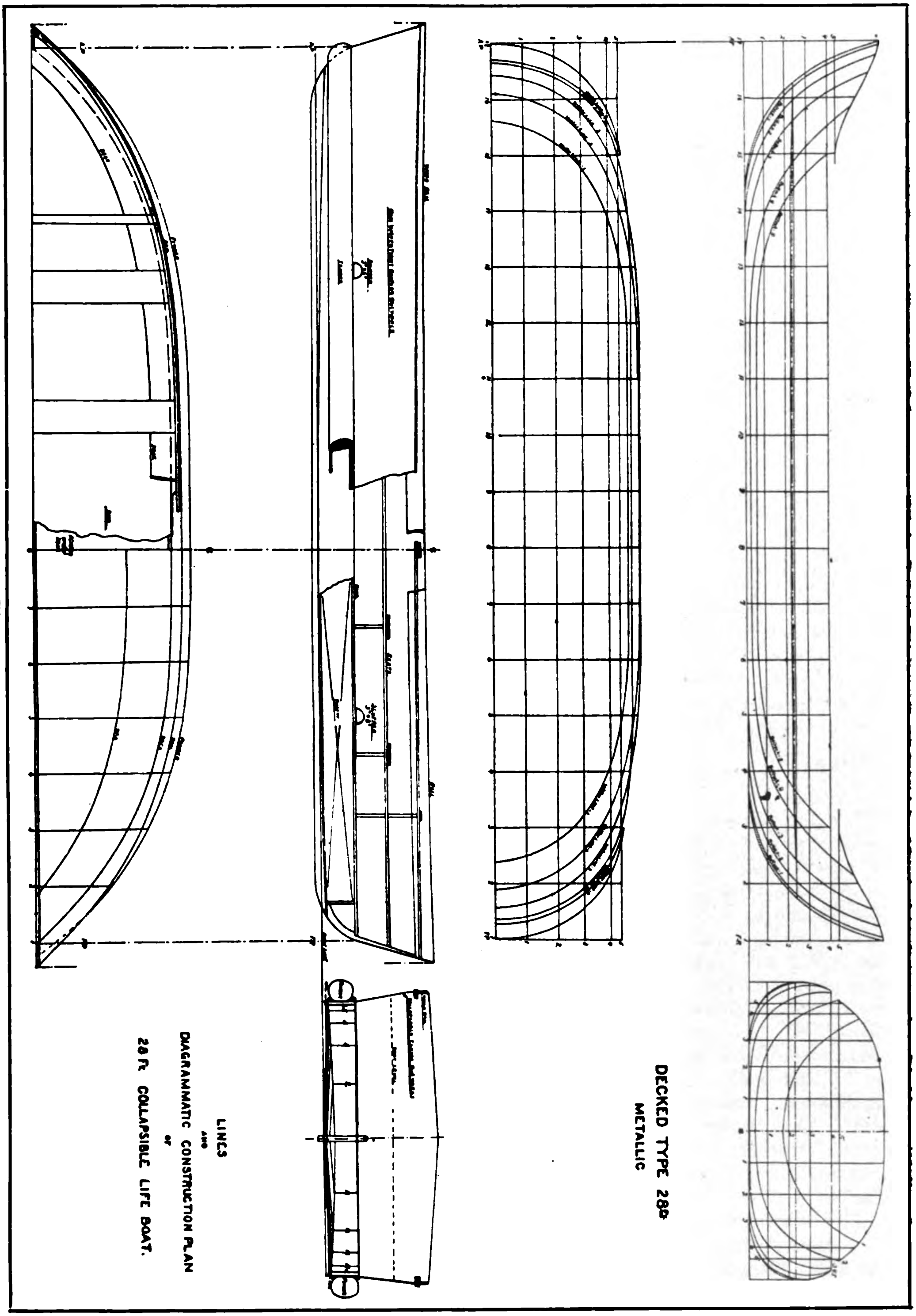

LINES
AND
DIAGRAMMATIC CONSTRUCTION PLAN
OF
28 Ft COLLAPSIBLE LIFE BOAT.
DECKED TYPE 28 Ft
METALLIC

Plate 1

TABLE OF CHARACTERISTICS OF FORM

Conditions	Met. Rad. B. M.	Met. Ht. G. M.	C. B. above base	C. G. above base	Mentacentre above base	Displacement. Lbs.	Draft above base	Type	Number
Light	5.55′	4.29	.41	1.67	5.96	3584#	.72	Standard—Metallic.	1
Loaded	3.58	1.39 / 2.04*	.86	3.05	4.44	10559	1.56		
Light	5.69	4.05	.35	1.99	6.04	2740	.56	Standard—Wooden.	2
Loaded	3.54	1.09 / 1.52†	.86	3.31	4.40	9784	1.44		
Light	11.31	9.21	.341	2.44	11.65	5392	.56	Decked—Metallic.	3
Loaded	5.67	3.10	.742	3.31	6.41	14462	1.31		
Light	6.43	3.14	.497	3.79	6.93	8840	.76	Collapsible—Wooden.	4
Loaded	5.23	.67	.614	5.17	5.84	12720	1.04		

* With load partly on bottom.
† This has since been done in the latest boats built by one of the large manufacturers.

struction plan in detail was not available for this type; but its general characteristics are shown by the figure on Plate 1. Compactness of stowage and suitability for nesting have been factors which have influenced appreciably the design of this type.

All boats were new, in the best of condition, and had been obtained direct from the makers.

In order to be of the most value, a basis for comparison must be used which involves either size or capacity. The former was chosen, and all boats were of the 28-foot size.

The inclining experiments were carried out using two plumb-bobs (one at each end) about 5 feet long. Pig lead was used for the inclining weights, and readings were taken with the lead on the center-line amidships, then to port, starboard and back to the center-line. The boats were in all cases in absolutely quiet water, and several readings were taken for each position with an agreement which was entirely satisfactory (seldom over one per cent).

The worst case as far as stability is concerned is when the boats are loaded to their full complement and that condition was simulated by loading the thwarts with sand bags (about 75 pounds each), so stowed that the center of gravity of each pair of sacks was at the proper height for a man sitting in that place. The height that this should be was determined by balancing a man fast to a plank in a sitting position and was found to be very close to 9 inches above the seat. Although two sacks averaged close to 150 pounds, the ballast was weighed each time it was put aboard in order to check the total weight. In most cases there were several persons in excess of the allowed load on board when investigating for the full load condition; but the resultant curves of stability, both statical and dynamical, have been corrected so they include only the number of persons that the inspection rules permit.

The table on this page gives the characteristics of form, centre of gravity, etc., of all types used:

Plate 3 gives the curves of statical stability (in terms of righting moment) for the boats in the fully loaded condition (allowable load) except in the case of the collapsible, and the table at the bottom of page 135 is derived therefrom:

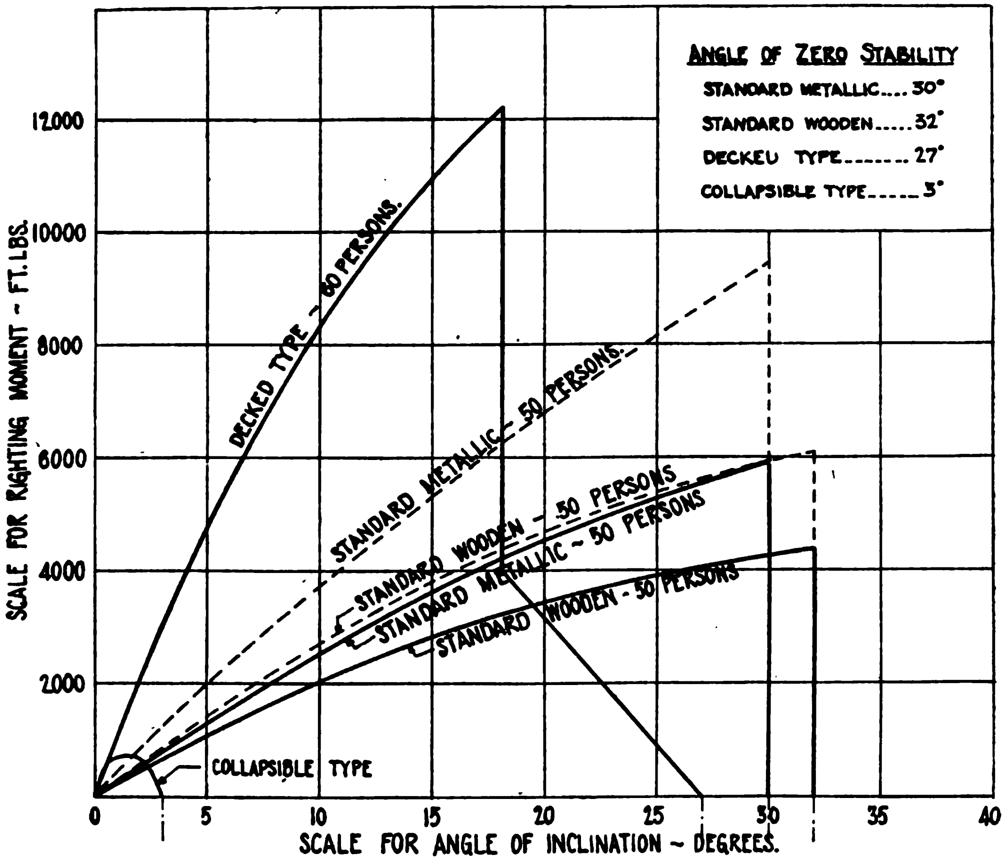


Plate 3

Angle of Inclination	Righting Moment in Foot-Pounds			
	Standard Metallic	Standard Wood	Decked Metallic	Collapsible Wood
5°	1300	1080	4780	Neg.
10°	2500	2030	8350	Neg.
15°	3620	2820	10980	Neg.
20°	4550	3440	3180	Neg.
25°	5300	3910	910	Neg.
30°	{ 5900 0* }	4280	Neg.	Neg.
Angle of Zero Stability	30°	32°	28°	3°

*Curve drops from 5900 to 0 at 30°.

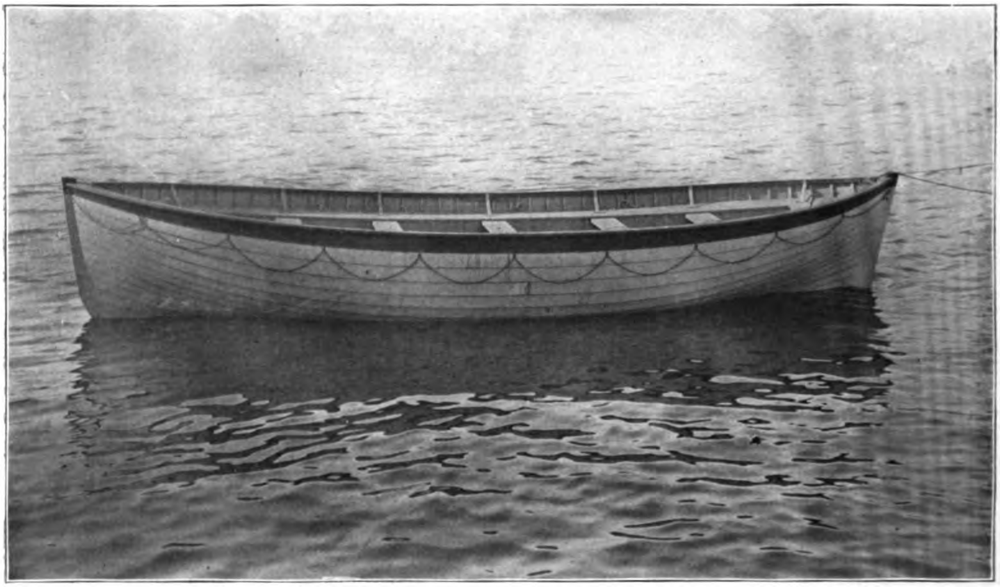


Fig. 1. 28′ x 8′4″ x 3′7″ Standard type wooden life boat, light condition

Fig. 2. 28′ x 8′4″ x 3′7″ Standard type wooden life boat, loaded condition, 50 persons

The open boats, Figures 1, 2, 3, 4, have a continually increasing righting moment until they reach such an angle that the rail goes under (30 degrees for the metallic and 32 degrees for the wooden) when the boat founders. The curves are normal and quite what one would expect, though it is of interest to note the very appreciable increase in stability which is caused by the seating of a portion of the passengers (15 in the metallic and 16 in the wooden) on the bottom of the boat instead of on the thwarts and seats provided for them. It is noticeable also that the

wooden boat has less stability than the metallic, though of the same external form. This was caused partly by the center of gravity of the boat itself being somewhat higher and partly by the fact that the thwart and seats were about one inch higher above the keel than in the metallic boat. The construction plans show no reason why the thwarts and seats should not be lowered appreciably and it would seem desirable to have them as low as possible.

For example the wooden boat from the cross curves has an uncorrected righting arm when loaded with 50 people and inclined at 30 degrees, of 0.90 feet. The distance of the center of gravity above the assumed axis of inclination is 11 inches, or 0.92 feet.

The correction for the righting arm is then $0.92 \times \sin 30$ degrees $= 0.46$ feet, and the corrected righting arm is $0.90 - 0.46 = 0.44$ feet.

Now if the thwarts were lowered 6 inches, the resultant center of gravity would be lowered 0.35 feet, in which case the correction would be $0.57 \times \sin 30$ degrees $= .28$ feet, and the corrected righting arm is $0.90 - 0.28 = 0.62$ feet, which is an increase in statical stability of about 40 per cent.

Probably the curves of dynamical stability on Plate 4 give the most comprehensive comparison of the merits of the different types from the stability view-point as they give the *work done* in foot-tons to incline the boats to the various angles. These were derived by integrating the curves of righting moments, using one of the Institute's integraphs for the work. The following tables are derived from these curves.

TABLE OF DYNAMICAL STABILITY—LOAD CONDITION

Angle	Work done in Foot-tons to incline to Angle			
	Standard Metallic	Standard Wood	Decked Metallic	Collapsible Wood
5°	.024	.020	.105	....
10°	.100	.078	.390	....
15°	.230	.173	.785	....
20°	.395	.300	1.155	....
25°	.580	.443	1.230	....
30°	.800	.600	....	....

DYNAMICAL STABILITY—LIGHT CONDITION

	Metallic	Wooden	Lundin	Collapsible
5	1630	700	4200	5600
10	3000	1350	6600	6000
15	4120	1910	8180	3120
20	5120	2400	9140	610
30	6700	3000	9700	neg.
40	7700	3100	8050	neg.
50	8200	2800	5280	neg.
60	8400	2350	2350	neg.

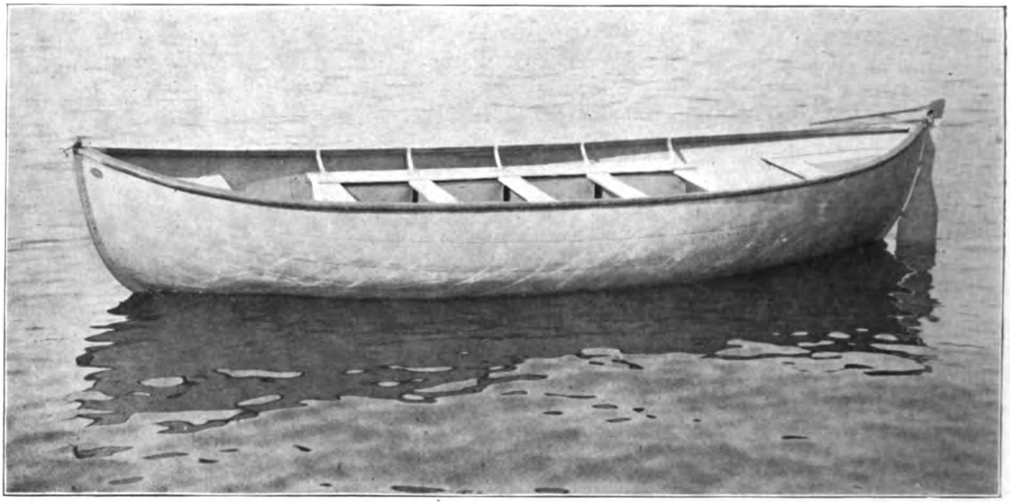


Fig. 3. 28′ x 8′4″ x 3′7″ Standard type life boat, light condition

Fig. 4. 28′ x 8′4″ x 3′7″ Standard type metallic life boat, loaded condition, 50 persons

Somewhat startling results were obtained with the collapsible boat. This was a new boat, obtained with the customary guarantee and was supposed to be in all respects ready for immediate service. It was of the dimensions given in the table and rated to carry 54 persons. When the inclining experiments in the light condition were made, the boat did not come to a position of equilibrium after the inclining weights were moved to one side, as the plumb-bobs showed a slow but continually increasing angle, the reason being that water was slowly leaking into the pontoon. The boat was hauled out and a few days later re-launched, hoping that it had swelled tight; but with the same result. A position of equilibrium was eventually reached after several hours in the inclined position and the center of gravity determined.

When it came to the loaded condition, the boat sank completely with 43 persons aboard, so that it was decided to accept for the load condition a less loading, one which would permit of the craft remaining

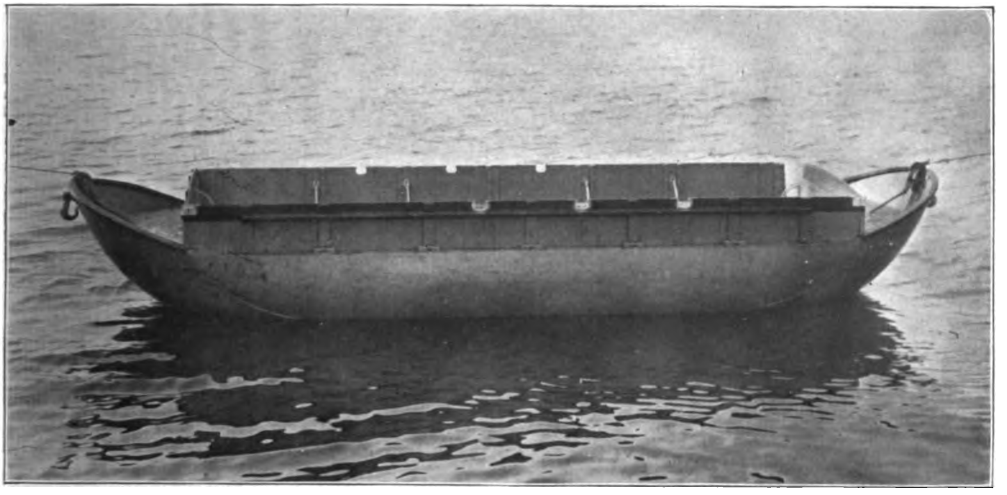


Fig. 5. 28′ x 9′4″ x 2′7″ Decked type life boat, light condition

Fig. 5a. 28′ x 9′4″ x 2′7″ Decked type life boat, loaded condition, 60 persons

afloat. Sixteen persons resulted in a freeboard of 1¼ inches to the top deck and this was the load used. The curve of righting moments when loaded with 16 persons, is shown on Plate 3 and it is interesting to note that the angle of vanishing stability is *three degrees*. The curve of dynamical stability is so small that it could not be shown on Plate. 4.

The failure of this boat to live up to a higher percentage of its requirements was undoubtedly due to the water leaking into the chamber between the decks and being gradually absorbed by the loose filling, buoyant material contained therein and placed there for the very purpose of providing sufficient buoyancy in case the covering of the pontoon is punctured.

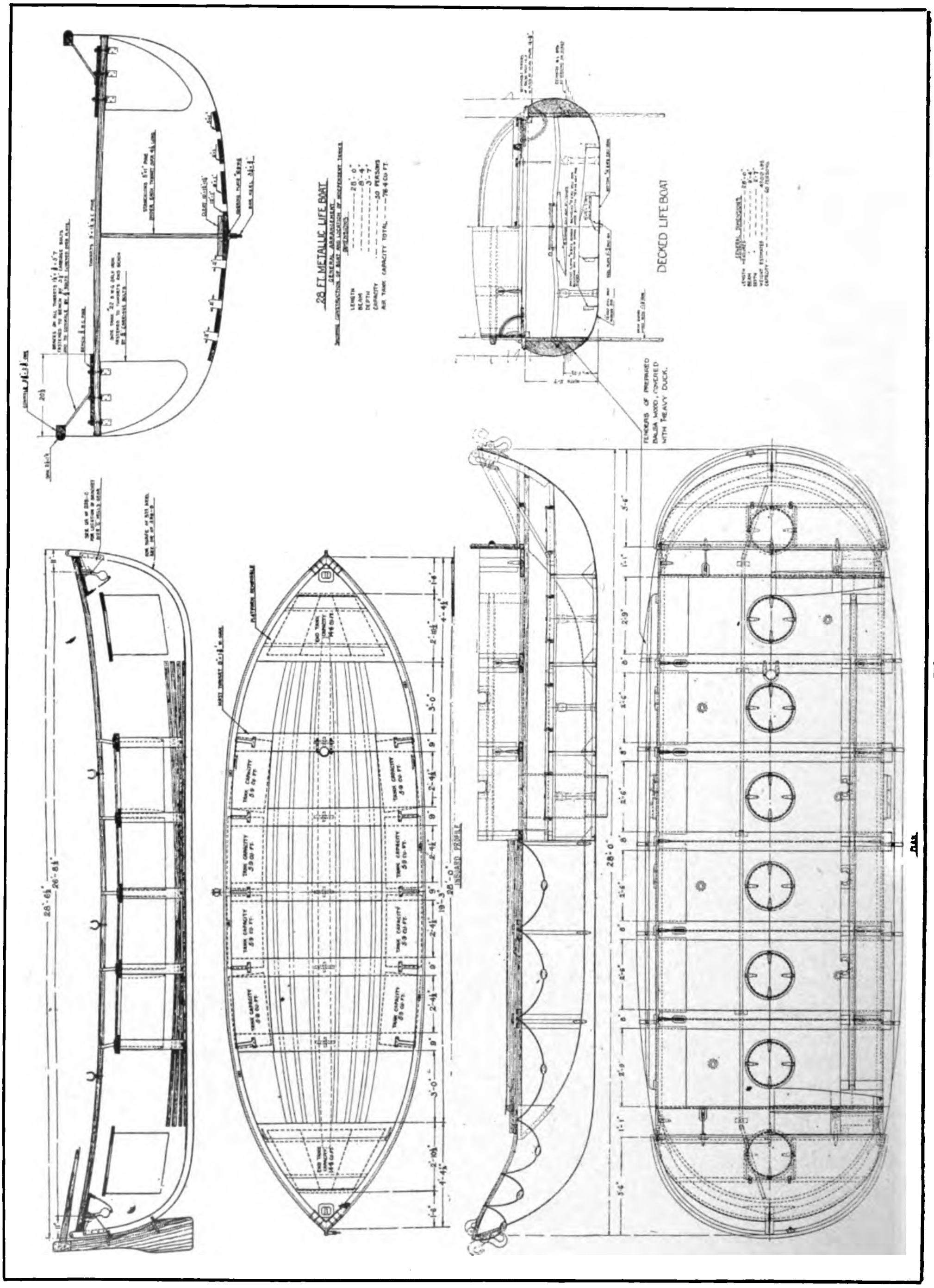

28 FT. METALLIC LIFE BOAT
DECKED LIFE BOAT
FENDERS OF PREPARED BALSA WOOD, COVERED WITH HEAVY DUCK
INBOARD PROFILE

Plate 2.

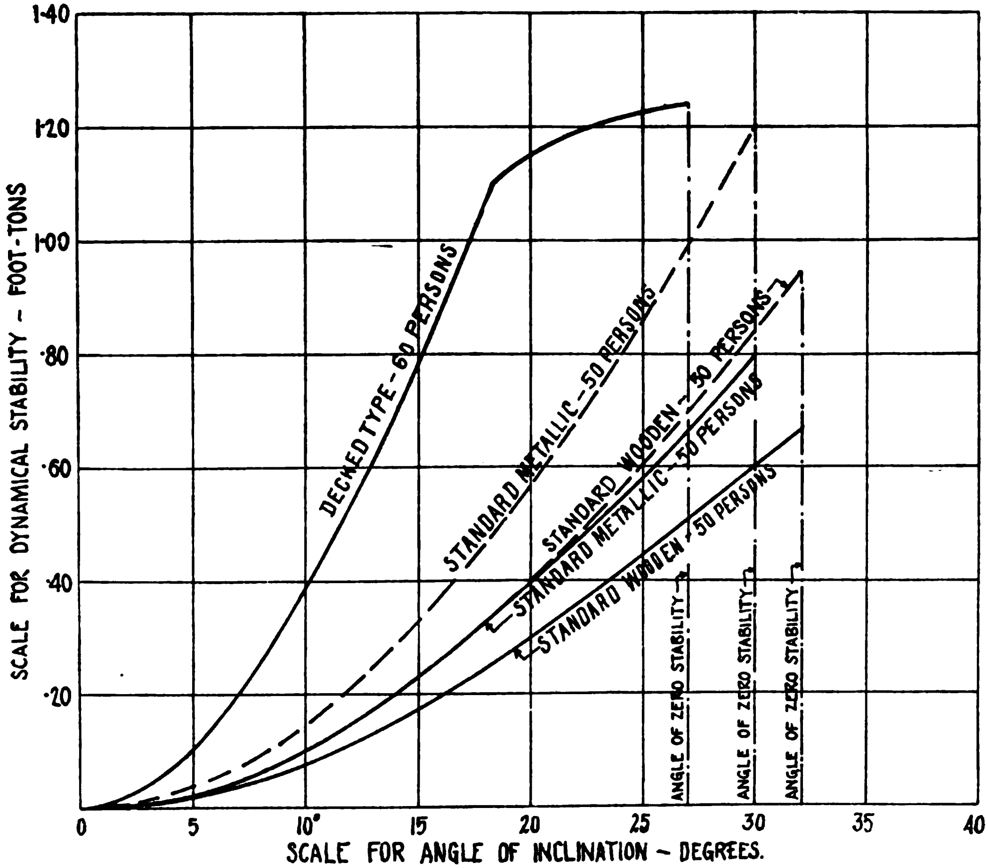


Plate 4

The essentially vicious feature from a construction point of view is that while water leaking in entirely eliminates the craft's stability and seriously impairs its buoyancy, the leakage is unknown and cannot be bailed out as in an open boat. Moreover, any wooden construction subjected to the ordinary weathering and wear encountered on the decks of ocean-going vessels will not and cannot be expected to remain water-tight. The bulwarks are not intended to be water-tight and the stability curve when light has all the characteristics of that of a raft, with its quick-rising curve of righting moments for very small angles and reaching zero stability at an angle vastly less than the standard type of boat. See Plate 3. The newer craft of this type are now built with metallic lower pontoons provided with internal water-tight subdivision which reduces the danger from free water inside but the characteristics are still essentially those of a raft more than of a boat.

LEGENDS OF THE BRIDGES

The breaking up of the isolation of Ceylon by the construction of a railway along the reefs, so that with one ferry the through journey may be made from the Continent, brings to mind the old Rama tale and, so comparing it with the story of the Giant's Causeway, one is struck by the wide distribution of the same

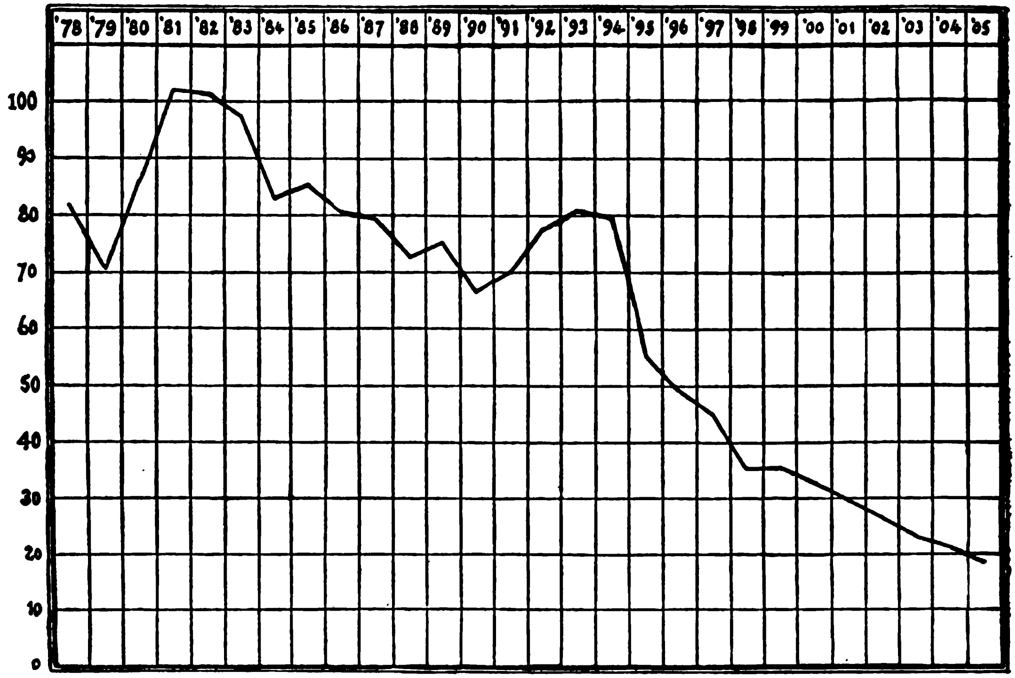
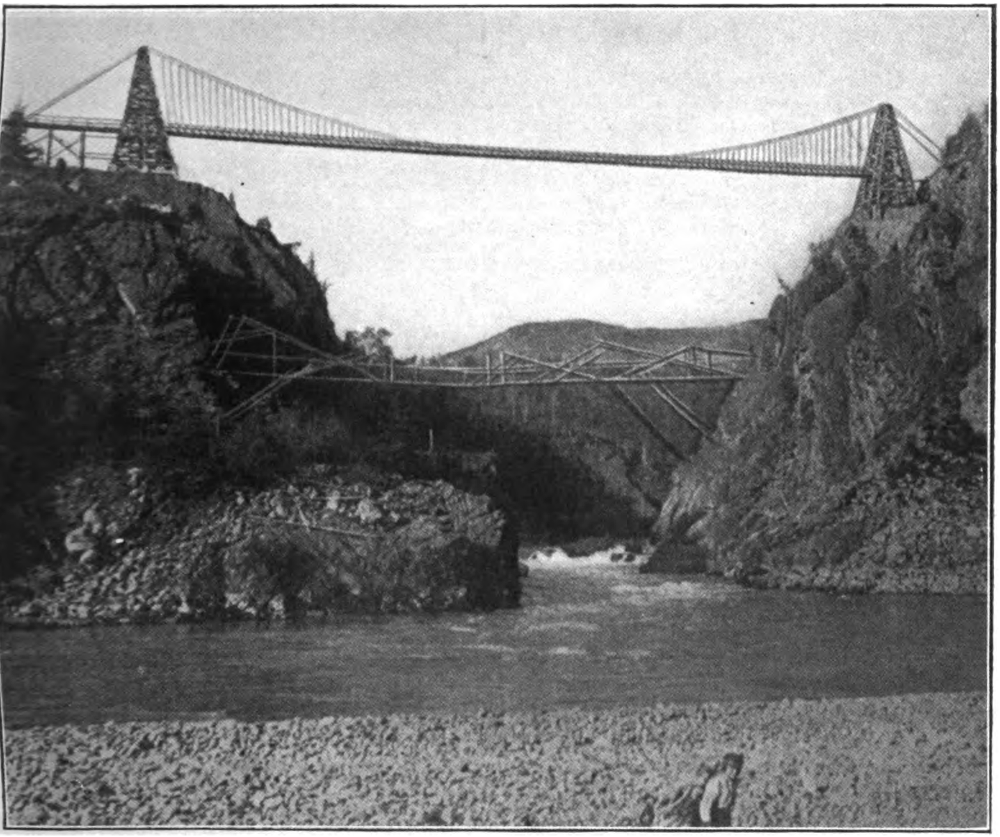


Chart showing the result of anti-toxin treatment in diphtheria. The curve represents the death rate from diphtheria per 100,000 of population in nineteen large cities of the world. Note the rapid fall in 1895, following at once the introduction of anti-toxin treatment in that year

legend. The two stories have naturally the imprint of their respective latitudes and peoples. In Ceylon, lying only ten degrees north of the equator, the bridge was for the rescue of a woman. Sita, the consort of Rama had been carried away by the demon king of Ceylon. Rama was aided by an army of monkeys and in five days (it ought to have been three or seven to be really consistent), the causeway was built. It followed the line of the reefs and Adams Bridge. Rama recovered his queen and in gratitude erected a temple on the island that has taken his name, Rameseram.

The northern bridge, whose great abutments of columnar basalt may be seen to this day on the Antrim County shore of Ireland and at the Isle of Staffa, was the work not of love, but of the rivalry of the northern Celts, whose weapons of old, the true ancestors of the shilaleh of Donnybrook, knew no brother. The bridge was built, the giants came over, though some legends have it that some waded, and sought the redoubtable Fin MaCool, who has a great variety of orthographies according to different authorities. Fin had tasted of the tree of knowledge by burning his thumb in cooking the king of the salmons, and whenever it was necessary to know anything some one reminded him to bite his thumb and thereupon the knowledge came to him. Fin was endowed with executive ability, that is to say, he made others do the things that were to be done. When the giants came over to finish him, he betook to the cradle and passed himself off as his own grandson, with his wife to do the tricky work and frighten the giants away. Fin was not a consistent Irish conception, and one would admire rather the faithful Rama in a holy quest, but the bridge connects more than Ceylon and Hindustan, it links the races of early man in a brotherhood little short of world-wide.

J. R., JR.



The Old and the New

The Engineering Record recently printed the picture of the two picturesque bridges shown on this page, which span the Bulkley River in northwestern Canada on the direct road to the Klondike. One is a modern suspension bridge, and the other is an old structure built by the Indians. This latter is the third of its kind that has been built here, the two earlier ones having been washed away by the river floods. It is an interesting example of Indian ingenuity, as no nails are employed in the structure, wooden pegs being used to fasten the members together.

It is stated that plants do not die suddenly through frost, but cell by cell, and death is retarded proportionally to the amount of undamaged tissue.

NEW MONT BLANC OBSERVATORY

An important visit of scientific men is planned to the summit of Mont Blanc, that of the building committee of the Society of Mont Blanc Observatories. For a good many years Janssen's observatory crowned the most lofty of the Alps, built for scientific purposes and in the hope that it would also serve for an Alpine cabin for mountain climbers. In the latter respect it was a failure, being very uncomfortable within.

The construction of the observatory followed what was probably the most remarkable mountain ascent on record, that of Janssen, the French physicist. He had the idea that from the top of the mountain, with the greater part of the

atmosphere below, it would be possible to make observations of the sun that would furnish much needed information. He expressed the intention of testing for himself the air at this level, notwithstanding his age and his inability to climb. For his trip he had constructed a narrow sled, with runners and with a long, overhead pole. Thirty guides were employed to propel the sled up and down the mountain following the usual route. In places only one runner touched, the sled being held in position by main strength by the guides. At one point it was declared impossible to drag the sled farther and Janssen alighted and tried to walk, but his strength was unequal to any effort and he could proceed at most but about one hundred feet. The ascent was accomplished; Janssen remained a day or two at the summit, and decided that science would be benefited by building the observatory.

The old building was much like the cabin of a ship. It was abandoned some time ago and has been swept away by the motion of the ice at the summit. In the meantime Vallot built a cabin on the Bosses, well toward the summit, a comfortable place which for a good many years has been doing splendid work in mountain meteorology.

On the death of Janssen, a few years ago, the present society of Mont Blanc Observatories was formed to care for the summit and the Bosses, and it is a committee of this society that has now raised the question of a new summit observatory. For the purpose some of its members will ascend during the present season and determine whether a new observatory is desirable. Mlle. Janssen, daughter of the scientist, is much interested and Vallot is one of the committee. In one respect the building of the new observatory will not be the tremendous task that the first one was. Since its erection the Swiss Alpine Club has placed cabins in all sorts of places nearly inaccessible: the Italians have put a hut high up on Monte Rosa and the technique of building at such heights has been pretty well established. Besides the guides are now quite accustomed to carrying up material and it is possible to secure it in portable form. J. R., JR.

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Science Conspectus

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VOL. V 1915 No. 1

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

VOL. V 1915 No. 1

THE MACKENZIE RIVER REGION

PHYSICAL FEATURES AND WONDERFUL NATURAL RESOURCES OF A COMPARATIVELY UNKNOWN TERRITORY COMPRISING A FIFTH OF ALL CANADA

BY CHARLES CAMSELL

THE Mackenzie is one of the great rivers of the earth draining an area 682,000 square miles in extent or about one-fifth of the total area of Canada. More than one-third of its basin is still a "terra incognita" to the white man and is known only to a few small roving bands of Indians of the great Chipewyan stock. This in spite of the fact that it is 125 years since it was first descended to its mouth by that noted explorer, Alexander Mackenzie. It is, however, recently beginning to attract some attention in the commercial world among men who are willing to exploit its natural resources. The agricultural portion, namely, that within the basins of the Peace and Athabaska Rivers, has been widely advertised as "The Last West" and is being gradually opened up and settled. This portion of the Mackenzie Basin, together with that immediately to the north of it as far as the Liard River and Great Slave Lake, contains the largest area of unoccupied agricultural land in Canada and is the direction in which Canadian agricultural expansion is bound to take place. The remainder of the basin to the north and east is still largely unexplored and while never likely to support a large agricultural population offers a vast field of possibly great value to the prospector. What this portion of the basin contains in mineral resources it is impossible to say and unsafe to hazard a guess in view of the surprises we have already received in opening up similar country in Northern Ontario. It is satisfactory to note that the Canadian Geological Survey is now embarking on a scheme for the exploration of the vast tracts of unknown territory in this and adjoining portions of Northern Canada.

PHYSICAL FEATURES

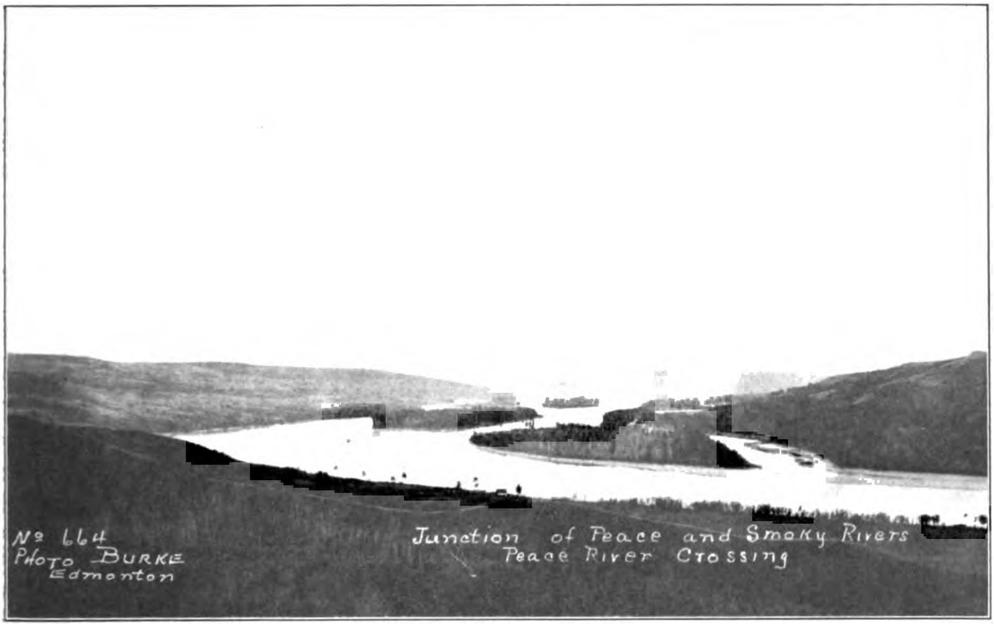
The Mackenzie River carries to the Arctic Ocean the drainage of 682,000 square miles of the northwestern portion of Canada. Its basin includes the northern parts of the provinces of British Columbia, Alberta, and Saskatchewan, and the western part of the Northwest Territories, covering from north to south about 16 degrees of latitude, from 53° to 69°. All the varieties of great land forms of mountain, plain, and plateau are included within its boundaries.

The basin of the Mackenzie River comprises three main physiographic provinces. On the west is the great series of parallel mountain ranges known as the Rocky Mountain system, rising more or less abruptly to heights which in the south often attain 10,000 feet and on Mt. Robson reach 13,000 feet, but in the extreme north rarely exceed 5,000 feet. Many of the stronger tributaries of the Mackenzie cut deeply into these ranges and some, indeed, such as the Liard and Peace, cut right through them, drawing some of their water from the western or back slopes of the ranges. The eastern boundary of this mountain region is fairly definite though not a direct line. Starting from a point about the intersection of latitude 53° and longitude 116° the line runs northwestward crossing the

The Mackenzie River at the junction of Great Bear River, showing one of the fault blocks (Bear Rock) that rises out of the Mackenzie lowland

Peace River about Hudson's Hope and striking the Liard River near longitude 125°. Here there is a great bay in the mountains and their continuity is interrupted by the Liard River which cuts directly through them. Under the name of Mackenzie Mountains they spring up again, however, immediately north of that river, but their eastern front has now been stepped far to the eastward and abuts on the Liard River at Fort Liard as if they had been displaced by a great fault along the valley of Liard River. From here the line runs northward touching the Mackenzie River at the mouth of Nahanni River and continuing thence along the western side of Mackenzie River to latitude 65° 30′, where it turns in a broad curve and sweeps westward around the head waters of Peel River. The Mackenzie Mountains which are one of the largest blocks of the whole Rocky Mountain system die out in this region but another, lower, range springs up north of Peel River and extends down to the Arctic coast, its eastern front following closely the valley of Peel River and rising as an abrupt fault scarp out of the delta of Mackenzie River.

The mountain province at nearly all points merges gradually by a decrease of elevation and a flattening out of the surface into the lowland province which occupies the central portion of the Mackenzie Basin. This province is a



The Valley of Peace River at the junction of Smoky River

broad northward sloping lowland through which the Mackenzie flows gently to the Arctic. It is a country of lakes and muskegs and of meandering streams flowing in moderately shallow valleys. The evenness of its surface is only broken here and there by a few rounded wooded hills or ranges such as the Cariboo Mountains north of Fort Vermilion, the Horn Mountains west of Fort Simpson, and an unnamed range of hills which lies east of the Mackenzie from Fort Wrigley to Great Bear River.

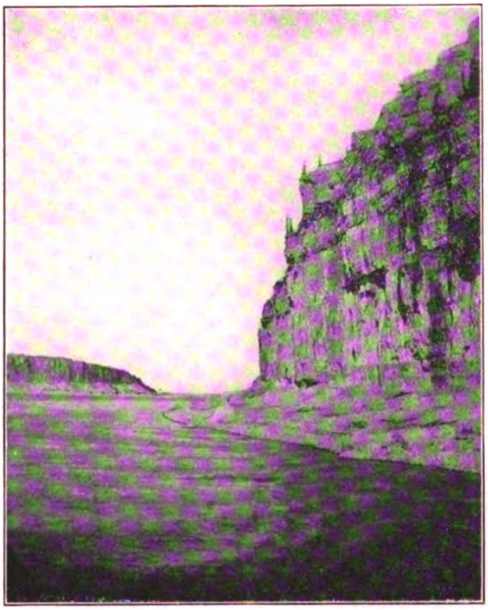
The Mackenzie lowland is the northward extension of the Great Plains region of the central part of the North American continent. It occupies a position in the north similar to that to the south through which the Mississippi flows southward to the Gulf of Mexico. In contrast to the Mississippi region, however, the Mackenzie lowland is forested to its mouth and it embraces within its limits three of the largest lakes on the continent.

The eastern province of the Mackenzie Basin is part of the great Laurentian plateau which occupies such a large part of northern and eastern Canada and almost completely encircles the great inland sea of Hudson Bay. The western boundary of this region is not sharply defined topographically but it coincides with the eastern border of the Paleozoic rocks which underlie the lowland region. It is a country of numerous lakes and of rivers flowing in ill-defined and shallow valleys. On a broad view its surface is level or rolling but in detail it is rugged, broken and rocky with little or no surface veneer of soil or loose material to cover the inequalities of the bed-rock. Its northern portion is treeless and is known as the Barren Lands.

The physical features of the Mackenzie Basin then are these: A mountainous highland on the west; a low-lying, rugged, rocky and partly treeless plateau on the east; and in the middle a broad, almost level, forested lowland with the trunk stream like a great artery flowing northward to the Arctic Sea, fed on one hand from the melting snows of the mountains and on the other hand from the numberless lakes of the plateau region on the east.

The Mackenzie ranks as one of the eight great rivers of the earth. Its length is reckoned at about 2,800 miles to the head of Peace River and its volume has been estimated to be about half a million cubic feet per second. It is exceeded on this continent only by the Mississippi in length, volume and drainage area, but it is greater in length and drainage area than the St. Lawrence.

It is a magnificent natural waterway allowing steamers of 5 feet draft to ascend without interruption from the Arctic Ocean 1,400 miles to the rapids on Slave River at Fort Smith. Above this it is navigable again for lighter draft steamers on the Peace and Athabaska Rivers for a total length of about 1,500 miles in three sections. Including its great lakes and those tributary streams which have already been explored it has a total length of navigable river and lake shore line of nearly 7,000 miles, interrupted, however, at three points, namely, the 16 miles of rapids on Slave River at Fort Smith, the rapids and falls on Peace River below Vermilion, one mile in length, and the 90 miles of rapids on Athabaska River above Fort McMurray.



The Ramparts of Mackenzie River, where the river cuts through vertical cliffs of Devonian limestone

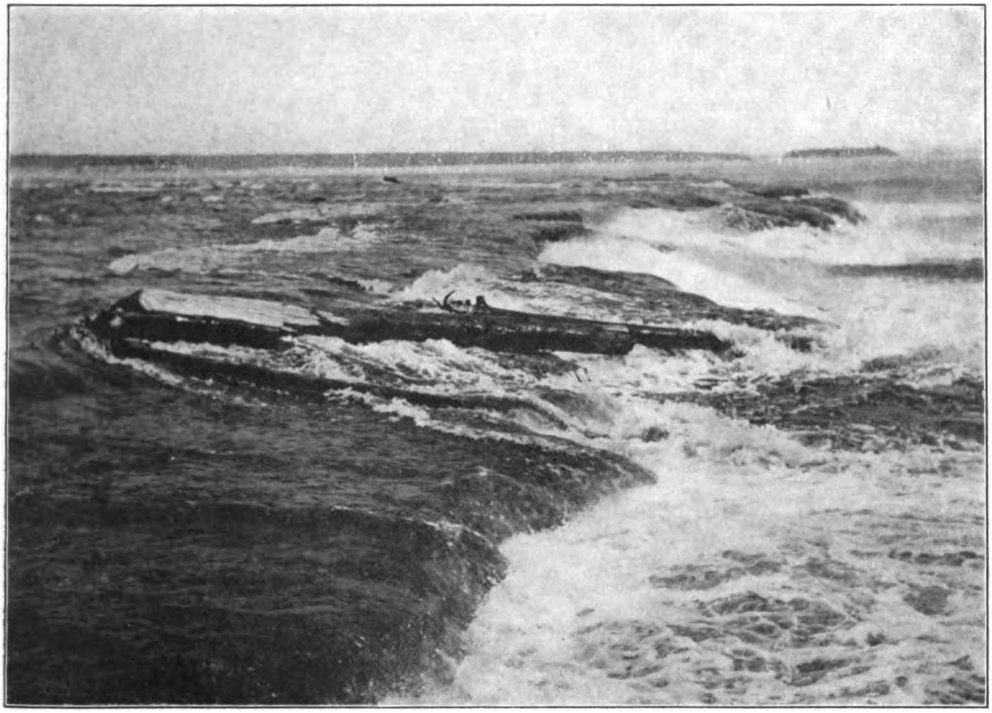
The following table presents the details of these navigable waterways, the distances being in round numbers:

NAVIGABLE WATERS OF MACKENZIE BASIN

	Miles
Lower Mackenzie River section:	
Mackenzie River, below Great Slave Lake	1,000
Peel River, to mouth of Wind River	250
Great Bear River	90
Shore line, Great Bear Lake	1,360
Liard River	440
Shore line, Great Slave Lake	1,440
Slave River, Great Slave Lake to Fort Smith	200
Total	4,780
Athabaska Lake section:	
Slave River, Athabaska Lake to Smith Landing	100
Peace River, Slave River to Vermilion Falls	220
Shore line, Athabaska Lake	560
Athabaska River, Athabaska Lake to McMurray	170
Clearwater River	80
Total	1,130
Peace River section:	
Peace River, Hudson's Hope to Vermilion Falls	550
Athabaska River section:	
Athabaska River, Grand Rapids to McLeod River	325
Lesser Slave River and Lake	115
Total	440
Total for whole Mackenzie Basin	6,900

Steamers ply on all four sections of the waterways of the Mackenzie Basin, but, as they are operated solely for the benefit of the fur-trading companies and the missions, they merely follow the main routes, which are the Peace, Athabaska and Mackenzie Rivers. Some of these steamers are equipped with passenger accommodation and it is possible for travellers to make the journey in comfort from the end of the railway line at Athabaska to the head of the delta and return by securing a passage from one of the fur-trading companies.

The season of navigation extends over about four months and in the southern portion of the region, namely, on the Peace and Athabaska Rivers, it is somewhat longer.



The falls of Peace River

These waterways are destined to become more and more important as settlement and development of the country advance because, as they have been in the past, so will they continue to be in the future the main highways on which the commerce of the country must be carried. Railways will supersede them to a certain extent, but only in the southern half of the region will they be likely to do so where the population will be mainly a farming population. Farther north where no industries are likely to develop that requires a large resident population the waterways will continue to be the lines of trade and transportation for years to come.

NATURAL RESOURCES

The natural resources of the Mackenzie River region include minerals, furs, timber, game and fish, and agricultural land.

To appreciate its possibilities in mineral wealth it is necessary to have some idea of the rock formations which comprise the geology of the region.

The eastern portion of the basin is covered by very ancient rocks of pre-Cambrian age. In this region are large bodies of granite or gneiss that have been intruded into older sediments and volcanic rocks of Keewatin and Huronian age of which only remnants are now left here and there in the granite batholiths. On this complex of igneous and sedimentary rocks rest patches of what are probably Keweenawan rocks.

The mountains on the western border of the basin are built up mainly of Paleozoic sediments which have been thrown by compression into a series of parallel ranges striking in a general northwesterly direction.

The lowland portion in the centre consists of flat-lying or gently undulating beds of limestones and shales of Devonian age, which are covered in the southern portion of the basin by a thick sheet

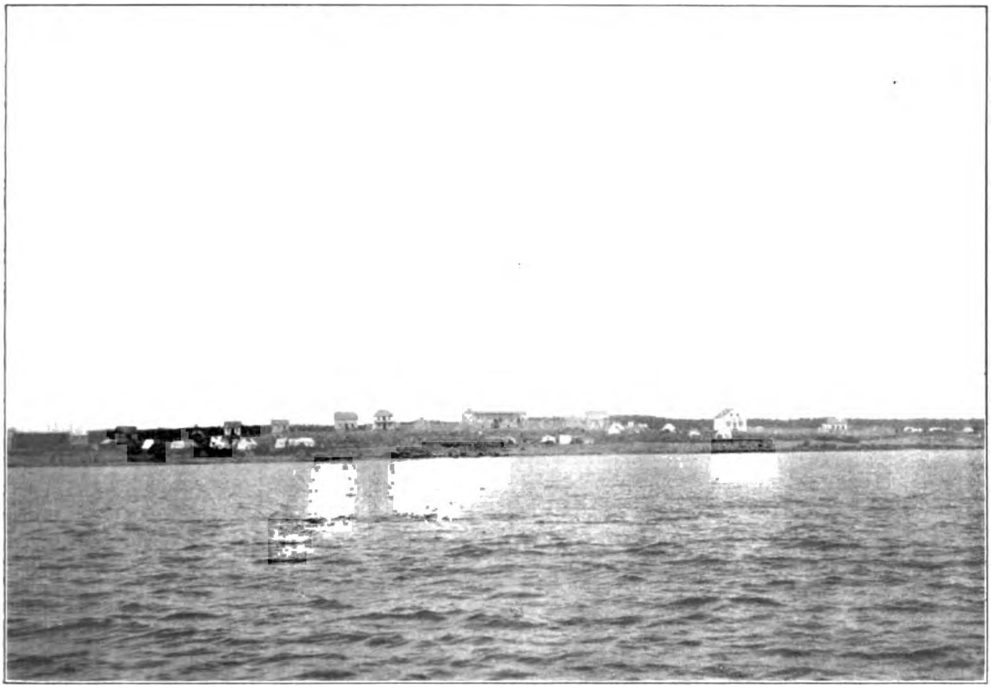
The Mackenzie River, a mile and a quarter wide at old Fort Wrigley

of Cretaceous sandstones and shales. Patches of Cretaceous rocks and smaller areas of Tertiary also rest on the Devonian floor in several places in the northern part of the basin.

The pre-Cambrian rocks of the east are known to contain iron, copper, nickel, and gold, but little is known of them beyond their actual occurrence in place and in no case has there been as yet any production of these metals. Iron ore occurs on the islands both of Great Bear and Great Slave Lakes. Copper ore is known at several points, but probably the most important locality is to the north and east of Great Bear Lake where it occurs in the native state in rocks similar to those on the south shore of Lake Superior. Evidences of nickel occurring under conditions similar to those at Sudbury, Ontario, have recently been discovered at the east end of Athabaska Lake. Gold ores are known in several places in quartz veins in the older pre-Cambrian sediments where they are cut by the Laurentian batholiths.

The pre-Cambrian of the eastern part of the Mackenzie Basin and of the region eastward to Hudson Bay is still virtually unexplored and these rocks comprise the largest area of unprospected ground on the North American continent. Elsewhere rocks of this age and character contain some of the greatest copper, iron, nickel, silver and gold mines of the world and it is not unreasonable to suppose that similar deposits will be found in this vast northern region.

The mountainous, western portion of the Mackenzie Basin, because it is made up mainly of sedimentary rocks, has not



Fond du Lac on Athabaska Lake, a typical northern fur trading post

the variety of metallic minerals that are found in the east. Coal occurs at several points on the eastern edge of this portion of the basin in rocks of Cretaceous age, and beds of salt and gypsum in some of the older rocks. Where, however, such tributaries of the Mackenzie as the Peace and Liard cut far enough back into the heart of the ranges to reach a region in which igneous intrusion has been active there again evidences are found of gold, silver, copper and lead ores. The Omenica district of the Peace River and the Cassiar district of the upper Liard have each produced placer gold amounting to several millions of dollars, and it is quite possible that in the great unprospected region north of the Liard River gold fields, if not as great, but of considerable importance, may yet be found. Of this there is already some evidence.

The lowland portion of the basin because of its being underlain by almost undisturbed rocks of a sedimentary nature is not likely to be rich in metallic minerals. It does, however, contain such non-metallic minerals as coal, salt, gypsum, oil and gas, and the metallic minerals, lead and zinc.

Coal occurs in abundance in the Cretaceous rocks of the Athabaska, Peace, and Nelson Rivers, and to a less extent in the Tertiary. Two of the Tertiary coal fields, namely, one at the mouth of Great Bear River and another on Peel River, are on fire and have been burning at least since Alexander Mackenzie descended the river in 1789. The fire is probably due to natural causes in spite of the Indian story that it was started by a legendary hero of theirs in order to cook his dinner of beaver.

Salt and gypsum are associated together at a number of points in Devonian rocks. Brine springs situated west of Fort Smith are the source of all the salt used in that northern country, while other brine springs and outcrops of rock salt occur at several other points, notably in the neighborhood of Fort Norman.

The most important mineral products

of the lowland portion of the basin, however, and possibly of the whole of this portion of Canada are oil and gas, evidences of which are found from the height of land on the south to the Arctic Ocean on the north. The original source of both these substances is believed to be in the Devonian rocks and since these rocks cover about half of the total area of the whole Mackenzie Basin the possibility of discovering oil pools of importance in this region is excellent. Gas has

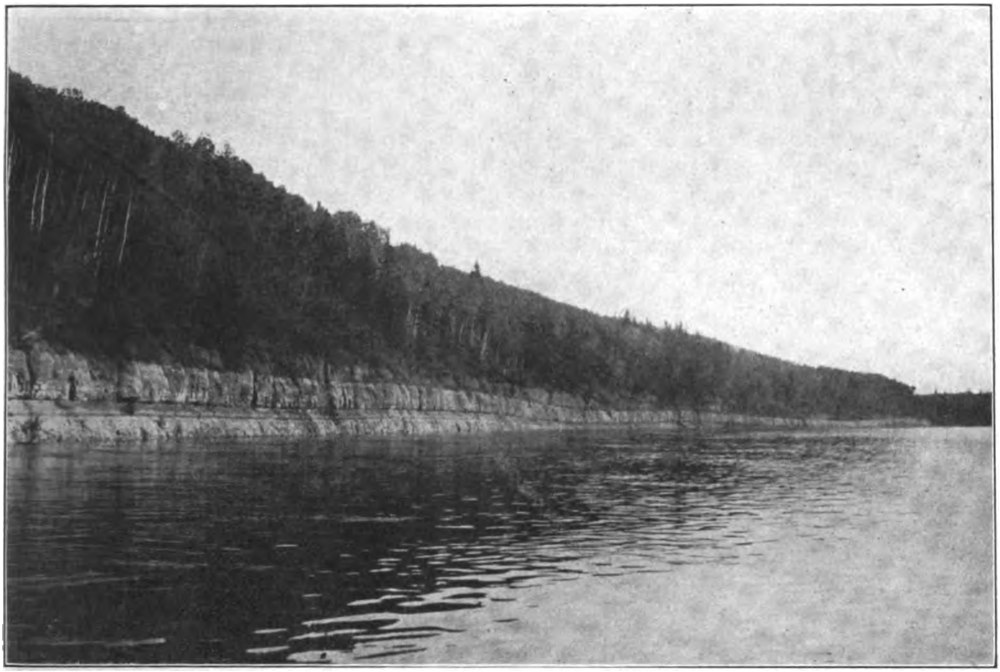
A lake trout from one of the great lakes of the Mackenzie Basin

been proven in great quantity by several drill holes, but little intelligent effort has so far been directed to the search for oil. Some drilling has been done on the Athabaska River but sites for the drill holes have more often been determined by the suitability of the ground for camps rather than by a study of the rock structure. The result has consequently been disappointing.

The fisheries of the great lakes of the Mackenzie, namely, those of Athabaska, Great Slave, and Great Bear Lakes, are among the most valuable of the assets of the region. Whitefish and lake trout are the principal fishes, and although fish is the principal food of the majority of the population and hundreds of thousands of pounds weight are consumed annually, this amount is so small in proportion to the quantity these lakes must contain that there is no evidence that they are being exhausted. Fisheries are made annually on Athabaska and Great Slave Lakes, but Great Bear Lake which contains the finest quality and the greatest variety of fishes, is virtually untouched. Whitefish in this lake go up to 12 pounds in weight, and trout to 50 or 60 pounds.

The fur trade is at present the most important industry in the Mackenzie Basin and with the exception of the farming and ranching communities in the extreme southwest of the basin virtually the whole population is more or less directly interested in this business. The history of the region is intimately bound up with the operations of the fur traders; and the few scattered settlements that are situated at intervals of 100 to 200 miles along the valley of the main rivers were originally established and are still maintained for the purpose of trading furs with the natives. Nearly all the different kinds of high grade furs such as fox, sable, mink, marten, ermine, lynx, beaver, otter, are obtained in the region, and the Hudson Bay Company, probably the greatest fur-trading company in the world, obtains the greater part of its furs from here. Canada exports over five million dollars' worth of furs annually and of this amount the Mackenzie Basin supplies probably one-third.

Of the agricultural possibilities of the region few people yet have any idea whatever, though the public is beginning to awake to the value of the land within the basins of the Peace and Athabaska Rivers, and railway lines are being built into this region with the object of settling it up. There is also a vast area north of the Peace River as far as Great Slave Lake and the Liard River of which we know little, though sufficient



Devonian limestone, underlying the lowland portion of the Mackenzie Basin. The limestone is here directly overlaid by the Tar sands of the Cretaceons

to prove that it is suitable for agricultural purposes. Altogether there is in this southwestern portion of the Mackenzie Basin an area of about 200,000 square miles suitable for settlement and there are no climatic or other reasons why a self-supporting population amounting to some millions may not live and thrive there on the products of agriculture. This whole region more than any other is the direction in which Canadian expansion in agricultural pursuits is bound to take place.

Forest products might be mentioned as another of the natural resources of the Mackenzie Basin. The whole of the basin down to the Arctic coast is thickly wooded with the exception of the northeastern border which is included in the so-called Barren Lands. The principal trees are spruce, tamarack, banksian pine, birch, and poplar. One of the uses to which these trees will eventually be put will be for the manufacture of pulp. The spruce, however, is a useful tree for lumber and it grows to sizes suitable for this purpose on the banks of all the streams even as far north as the delta of the river. Large areas have been burnt and the timber destroyed by the natives because they say that it improves the hunting. Forestry protection, however, is being undertaken by the Government and the effects of this are already noticeable in the decreasing number of forest fires.

The natural resources of the Mackenzie Basin are sufficient evidence that its future is assured, for there are no difficulties, climatic or topographic, such as to prevent men of means and enterprise from entering and remaining in the country to develop these natural resources. Settlement of course must begin at the south and progess northward until the limit is reached. The northern limit for the settlement of an agricultural population in any great numbers will probably be about latitude 62° north, but there are no doubt numbers of chances for mining communities to spring up north of this and in the less hospitable country that forms the rocky region along the eastern edge of the Mackenzie Basin.

COMMERCIAL GLUCOSE AND ITS USES

A MUCH MISUNDERSTOOD AND MALIGNED PRODUCT—NECESSARY FOR CERTAIN FOOD STAPLES AND A GOOD SUBSTITUTE FOR MORE EXPENSIVE INGREDIENTS

BY GEORGE W. ROLFE

Most well-informed people know that in the early part of the last century Kirchoff was the first to describe a sugar made by boiling starch with dilute sulphuric acid, and that this sweet, subsequently found to be other than cane-sugar was called "glucose" or "grape-sugar." Later it was termed "dextrose" when in the progress of science it became necessary to distinguish the individual from a whole family of "glucoses" which had been discovered.

Nowadays, most of us have heard of "glucose" as a commercial product of doubtful reputation. People look askance when glucose is mentioned. Confectioners and grocers make haste to deny that glucose ever appears in their products. Glucose is classed with harmful food adulterants, and has been called by pure food experts the "champion adulterant" of all. It has even been depicted in cartoons as a devil with hoofs and horns. Glucose has also been called "mucilage," the implication being that it is only fit for postage-stamps and not for human stomachs. This may be why many associate glucose with glue. The names sound alike and both are sticky, but the reasoning is like assuming that all gentlemen are gentiles. Glucose makes a rather poor adhesive, but one who is hard put for mucilage might so use it with indifferent success just as it is possible to use tapioca pudding, molasses or other sticky foods.

Turning to the advertising literature of the glucose manufacturers, we note that many eminent authorities laud glucose as most wholesome, that it is the principal sweet of fruits and one of the intermediate products of the digestion of starch in the human organism, is found in the blood,—and similar statements, all of which like the damning ones of some pure food experts are "important if true."

Notwithstanding that annually between thirty and forty million bushels of Indian corn are made into glucose, comparatively few except those engaged in the numerous industries in which glucose enters, ever see the product. The idea of the general public, professional as well as the laity, seems to be that glucose is mostly composed of grape-sugar which is made according to the Kirchoff method by boiling starch and oil of vitriol and neutralizing the mixture with chalk. Many supposedly up-to-date cyclopaedias make such statements.

Much of the ignorance concerning this important food product is due to the following facts: Pure commercial glucose is practically unknown in household cookery, and so is not sold in a package convenient for household use. While it is in multifarious food products found on the grocer's shelves it is rarely seen there in its original state. This is equally true of raw sugar. Years ago, raw open-kettle sugars were familiar to all New England housewives and were used by them in cooking. Raw sugars made by modern processes are used to some extent now in England and European countries, but nowadays few of the citizens of this country, outside of the sugar producing districts, ever see raw sugars, which are sent directly to the refineries in packages weighing several hundred pounds each and in a condition not fit for domestic use. Glucose, like refined sugar, is manufactured in comparatively few factories, and these of large capacity, for the manufacture of glucose requires a large outlay of capital and consequently large output. The cheapness of the prod-

uct makes its manufacture profitable only on a large scale. This is equally true of sugar.

What is commercial glucose? In general appearance it is a transparent, very viscous sirup, often practically colorless but usually of a light straw color, sweet, but with little if any other flavor. For this reason, glucose, like sugar, has been termed a "neutral sweet,"—not neutral in the chemical sense—although such products are always chemically neutral within practical limits of testing—but so called because when pure they have no characteristic flavor other than sweet and will take any added flavor unchanged.

Glucose is not made by use of oil of vitriol and chalk, nor is glucose, in the ordinarily accepted sense of dextrose, its characteristic ingredient. The trade name "glucose" while well established by custom of years is no more suited to the present product than is "chloride of lime" to bleaching powder or "hyposulphite of soda" to the commercial salt sold under that name. It is true that the basic process by which glucose is made from starch is on the lines of Kirchoff's original experiment, but the methods are quite different. The "starch milk," a suspension of the granules in water, is pumped into large pressure boilers of gun metal, and is cooked for about ten minutes with a few tenths of a per cent. of hydrochloric acid (commercial muriatic acid) under a pressure of about 50 lbs. of steam. The starch is not treated long enough by this process to convert it entirely into grape sugar (true glucose), only about 20 per cent. being produced. There is, in fact, less of the glucose sugars, properly so called, in commerical glucose than occur as natural ingredients of cane sugar molasses, and far less than in honey, which is composed almost entirely of glucose sugars, nearly half of which is dextrose (grape sugar), this being the sugar which separates out when the honey granulates.

Commercial glucose as now made contains less than 20 per cent. of true glucose sugars, the rest being a mixture of malt sugar (maltose) and dextrins, more or less in chemical combination in the approximate proportion of nine parts of maltose to seven of dextrin. In percentages of total sugars and dextrins, there are in round numbers,—maltose, 45 per cent., dextrose, 20 per cent., dextrin, 35 per cent., the proportions varying somewhat in different lots.

These three carbohydrates, *dextrose*, which is a true glucose sugar, *maltose*, belonging to the cane sugar family, and making up nearly half of the total, and *dextrin*, a gummy ("colloidal") substance closely related to starch paste, compose over 99 per cent. of the solid matter of refined commercial glucose. This composition has been found to be the most desirable for imparting to the product the properties most suited for a sirup which can be refined readily, and at the same time contain enough colloidal material to prevent its crystallizing at any concentration. This colloidal matter also renders the sirup capable of dissolving considerable amounts of cane sugar without crystallization. Such a product is peculiarly valuable in the preparation of sirups, candies, preserves, and jellies, quite apart from its use as a sweet. It also contains nearly the maximum amount of malt sugar that can be produced by such a process.

The rest of the dissolved substance of commercial glucose consists of 0.3 to 0.5 per cent. of mineral matter, mostly composed of sodium chloride from the neutralization with soda of the hydrochloric acid used in the manufacture, sulphites which are added at various stages, phosphates and other salts from the natural mineral matters present in minute quantities in the starch or coming in part from the boneblack used in the refining process. There is also about 0.08 per cent. of nitrogen corresponding to five or six times its weight of organic substances from the gluten left in the starch. Much of this nitrogenous matter is not gluten, but simpler organic compounds resulting from the action of the acid (used to convert the starch) on the gluten. These nitrogenous matters have much to do with the quality of the

glucose, and it is on this account that they are of peculiar importance although present in minute amounts. The impurities from the gluten which are less acted upon by the acid, the "albumoses," give trouble to the candy manufacturer by causing foaming in his kettles, while this property is the joy of the brewer. Those gluten substances which are changed further by the acid, the "amino bodies," tend to make the glucose darken and also impart a flavor which though barely perceptible is disagreeable—bitter or fishy. Manufacturers used to correct the objectionable effects of these impurities by the addition of sulphites to the glucose but this was but a temporary expedient and undesirable in a food product. Glucose has been much improved in recent years by practically eliminating the effect of these impurities by more efficient purification of the starch used in its manufacture.

The glucose process does not end with the acid treatment of the starch and the neutralizing, as at this stage the dilute sirup is far from pure, containing oily matters from the corn, some undecomposed gluten and other impurities mostly in suspension. This liquor before it is concentrated to a sirup of about 80 per cent. solids undergoes a refining with boneblack closely resembling that of cane sugar, the apparatus being practically identical—filtering through bags and boneblack filters—but in the case of glucose all impurities affecting the quality of the sirup have to be removed or destroyed as there is no purification by crystallization.

Hence, glucose, like granulated sugar, is one of the purest food products in use, however pernicious the properties that may be ascribed to it.

Space does not allow a detailed description of glucose manufacture which is of great interest owing to the numerous by-products which are made, and also because while glucose is the chief in output, its manufacture is only one of many starch products carried on at the same time.

The following table, taken from an advertising circular of a manufacturer, shows in a concise way how the different parts of the corn kernel are utilized:

Parts of Corn Kernel	*Composition*	*Products*
1—Germ	Oil and Oil Cake	Corn Oil, Corn Oil Cake, Corn Oil Meal.
2—Endosperm (Body of the Corn)	Starch	Dry Starches, Dextrines, and, by conversion, Corn Sirups [glucose] and Sugars.
	Gluten	
3—Hull	Bran	Gluten Feed.
4—Water added for steeping	Soluble Substances of Corn	

The oil is used principally for soap and for making vulcanized products used for rubber substitute. The oil-cake and meal from the cake are used as cattle feed. The gluten and bran from the starch, mixed with the soluble matters extracted by the water used to soften ("steep") the grain before grinding is made into "gluten feed" also for cattle. All these are valuable by-products for which there is a good market. The starch in a moist state, known as "mill starch" is the raw material for making the various goods which are sold under the names of "glucose" ("corn sirup"); "corn sugar" ("grape sugar"), the latter a hard product which is largely composed of dextrose, but never known in trade as "commercial glucose" and little used as a food product; "dextrins," true adhesives which are usually made by roasting starch and entirely different in characteristics from the dextrin ingredient of commercial glucose; besides numerous "dry starches" used by laundries, confectioners, and in many other industries as well as for household purposes.

At present prices, commercial glucose, a sirup containing about 80 per cent. of the pure carbohydrates in solution sells at about 2¼ cents per pound (26–28 cents per gallon) or at about 2.7 cents per pound of actual dissolved substance. Is its sole use that of an adulterant of better food materials as some food reformers claim? Is glucose used to adulterate our ordinary grocery sugars?

It is well known in the history of the industry that some thirty years ago a Chicago concern spent some millions of dollars and much valuable time in

trying to adulterate fine grained white sugars with solid grape sugar of high quality, made from starch, but the attempt failed miserably simply because the stuff would not stay mixed and the grains "set" in a solid mass after a short time. In years gone by, glucose was also much used to mix with cheap, poor grade molasses making a brighter, more attractive product which, so improved, could be sold at the price of higher grade molasses. This form of adulteration is so easily detected that it is rarely resorted to in these days of pure food legislation. The last case which came to the writer's notice was one of a New York molasses dealer who was heavily fined for having a few per cent. of commercial glucose in his molasses although his defence was a plausible one—that the glucose was some accidently left in the barrel, old glucose barrels being much used for tropical molasses shipments.

Glucose is now used in a legitimate manner to mix with cane-sugar sirup in the proportion of 85 per cent. of glucose to 15 per cent. of sirup, a little salt and sometimes vanillin being added to improve the flavor. The cane-sugar sirup is usually refinery molasses ("barrel sirup") which imparts the principal flavor. These mixed sirups are sold openly as glucose or "corn sirups" and as their flavor is superior to the original molasses there seems to be no reason why they are not wholesome food products for legitimate trade, even though some people there are who prefer, the flavor of the sirups made from the natural cane juices and are willing to pay the higher price for such. Certainly, such glucose sirups are preferable to the average grocery molasses either from the standpoint of the epicure or the sanitarian.

Commercial glucose is used in large quantities in the manufacture of cheap jams and preserves. Apple cores and skins from fruit in its preparation for evaporation or preserving are the basis for most cheap jellies; the pecten substance and juice being extracted by the usual processes of jelly making and mixed with glucose and sugar forms a jelly material to which other fruit juices are added. The law requires such jellies to be plainly described on the label so that the consumer is informed that he is using a jelly made of apple and glucose with a fruit flavoring, and is at perfect liberty to buy the pure glucose-free fruit product if he so prefers. What interests the public is: Are these cheap jellies unwholesome, or is there other reason why the man with the slim pocketbook should not buy them? This question is quite apart from whether they contain glucose or not, but deals with the soundness and wholesomeness of the ingredients used and the cleanliness of their preparation.

By far the largest amount of glucose is consumed in the manufacture of candy, the peculiar properties of this sirup making it especially valuable in this industry, as has been explained. The requisite for most candy is that it should not "grain" (crystallize), and glucose, owing to its colloidal nature, is the most effective and wholesome substance to prevent this. The popular impression that glucose is used in candy-making because it is a cheap substitute for sugar and that its sole function is to give sweetness is only approximately correct.

How sweet is glucose relative to cane sugar? Determinations of the sweetness of a saccharine product are very unsatisfactory owing to personal equation and also to the influence of the other mixed ingredients and even the physical condition of the substance tested.

Granulated sugar tastes sweet. Powder it in a mortar and it will taste less sweet. Owing to this fact it is hard to convince some people that powdered sugar is not adulterated, although this practice, easily detected, is practically unknown at present. A quarter of a grain of quinine mixed into a pound of granulated sugar is said to make it taste sweeter. Common salt in small quantities will improve the sweetness of cake and other sweet foods, as all cooks know. Raw sugars, even when they contain negligible quantities of the sweeter mother-sirups, taste distinctly sweeter than granulated sugar although their actual sugar content is less. This is due to the salts

and extractive matters in the raw product, and it is why many cooks sigh for the old-fashioned open kettle sugar and even prefer the refiners' imitation goods to granulated in making their apple pies.

Relative tests of the sweetness of cane sugar and glucose (*dextrose*) have been made by dilution experiments on the pure sugars, but as far as the writer knows, no relative tests of the sweetness of commercial glucose as now made have been published. Taking this value to be .5 for the solids in glucose, sugar at 5 cents is cheaper as a sweetener than glucose.

As a matter of fact, very little candy is made with glucose as the only sweet. Usually, candy contains 60 per cent. or more of cane sugar, the sweetening of the glucose being of much less importance than the other properties it imparts to the mixture.

It seems reasonable to infer that commercial glucose rather than being a serious competitor of cane sugar has really increased the consumption of the latter, especially in candies. Because of the great advantages from the use of glucose in candy-making, the industry has had an impetus which has greatly increased sugar consumption.

The relative wholesomeness of candies made from glucose and those made from cane sugar has never been decided, and may never be. The dextrins of "glucose" as now manufactured are in great part in combination with the malt sugar and seem in every way identical with the malto-dextrins obtained by the action of malt on starch, and are digested more in the intestines than in the stomach as compared with pure sugar candies. Whether this is an advantage or not, the physiologists must decide.

Glucose is extensively used in industries not making food products. It is used in cheap soaps, for "filling" leather and tanning extracts, and as many of its uses in such industries are apparently for adulteration such practices have no doubt added to its reputation as the "champion adulterant." As was pointed out in an article in a previous number of this magazine,* on the industrial uses of sugar, the highly respectable beet sugar of 99 per cent. purity is used in Europe for precisely the same purposes, the choice between sugar and glucose as a "filler" being merely a matter of price. Cane sugar has also been used extensively to "fill" coal-tar dyes and adulterate chocolate without having its respectability seriously impugned.

In view of the undoubted commercial importance of glucose as a food product it would seem as if its value in dietetics and food economics, as well as its relative wholesomeness, ought to be studied in the light of a proper knowledge of its special characteristics. To call glucose "mucilage," or to ascribe to it properties of a dextrose solution is either ignorant or dishonest. As far as the use of glucose as an adulterant is concerned, it is the function of the Pure Food Laws to protect the public from these practices, and such obviously are quite apart from the legitimate and open use of glucose, sugar or any other cheap and wholesome food product as a satisfactory substitute for more expensive ingredients, and the propriety of such a substitute always will be its suitability for the purpose and its cost.

If legislation is appropriate for forbidding the extravagant claims of manufacturers and dealers as to the superiority of their food products, why not legislation to prevent irresponsible statements of "pure food" authorities which are condemnatory? Certainly, the one is as important for the public interest as the other.

INFECTION FROM TOWELS

Recently an investigation has been carried out by Zinsser and Hopkins on the viability of the *Spirochæta pallida*, the organism causing syphilis, when exposed on a towel to diffuse light at room temperature. By moistening pieces of towel with a culture of the organism and then exposing it for various periods they found that infectivity could still be demonstrated at the end of eleven and one-half hours. Since the lesions of secondary syphilis are often found on the face, the danger of the common towel and the possibility of innocent infection are clearly shown. E. A. I.

*Science Conspectus No. 2, 1913.

SALT AND ITS RELATION TO NUTRITION

CARNIVORA EAT LITTLE SALT — THE DESIRE OF VEGETARIAN ANIMALS FOR SALT PROBABLY DUE TO EXCESS OF POTASSIUM OVER SODIUM IN THEIR FOOD

BY PERCY G. STILES

COMMON salt is a commodity, the annual production of which is known to exceed 12,000,000 tons. Of this huge total a large share is used as a preservative or otherwise employed in industry, yet an immense quantity is deliberately added to the diet of mankind. It is said that an individual consumption of 20 grams a day is not unusual. This average, sustained for a year, would amount to about 17 pounds. The ration appears surprisingly large when we observe that it may be as much as one quarter of the total weight of protein taken and equal to one twelfth of the combined starch and sugar which constitute our main dependence for running the human engine.

It is agreed by all writers on the subject of nutrition that only a small part of this salt consumption is necessary. The rest is dictated by appetite: it is due to the common liking for the salty flavor. Individuals are found who do not care for this and who are said to eat no salt. This means that they use none voluntarily at table and perhaps direct that none shall be used in the kitchen. Yet they continue to receive a small salt ration because some is present in most foods and there is reason to believe that this minimal supply cannot be dispensed with. Sodium chloride is the chief salt in the blood and in the other fluids of the body. It is accordingly plain that growth cannot be continued unless this compound is furnished along with the other necessary nutrients.

When full stature is reached the need for salt is doubtless diminished. It might cease entirely if it were possible to avoid all loss of salt in the excretions. This possibility is nearly but not quite realized. When a man fasts for several days the escape of sodium chloride from his system sinks to a low level but remains appreciable. It may be in the vicinity of 0.6 gram in the twenty-four hours. In complete starvation this gradual loss is probably not out of proportion to the general reduction of weight. Hence it does not lead to an actual lowering of the percentage of salt in the body. A diet sufficient in all other respects, but lacking salt, might bring to pass such a lowering.

One interesting result of using a salt-free diet has been observed in the failure of the glands of the stomach to produce hydrochloric acid. This valuable aid to digestion and antagonist of putrefaction must be evolved from the chlorides of the blood. Apparently it is not secreted when the concentration of these substances in the blood is at all below the normal and this in spite of the fact that the chlorine ions of the gastric juice can probably be recovered quite successfully. The suggestion has been made that rigid restriction of salt should be beneficial in cases where the gastric acidity is excessive.

Bunge, an Austrian physiologist, has collected a great volume of data concerning the habits of different races as to the use of salt. It is evident that some people set a high value upon it while others do not care for it at all. Where it is prized it has often figured in maxims and metaphors. "To earn one's salt" is a familiar phrase which gains point from the common origin of the words "salt" and "salary." Bunge learned that a certain East Indian tribe used as the most solemn oath in their court procedure the formula, "May I never taste salt again if I speak not the truth."

A little investigation shows that the desire to add salt to the food is experienced most by those who are vegetarians

or nearly so. Men who are strictly carnivorous abhor salt. Thus it was found by the agents of the Russian government that the natives of Kamchatka could not be prevailed upon to salt the fish which formed their entire diet. The supply of fish was uncertain and that which was saved to eat in the long intervals between catches decomposed in shallow pits. Still it was preferred to salt fish. We notice the same detestation of salt among carnivorous animals. They present a marked contrast to many of the herbivora, like cattle, sheep, and deer, which are very fond of salt.

The Arctic explorer Stefansson has recently reported a striking instance of the objection to salt which accompanies the use of a flesh diet. The Esquimaux, whom he knows so well, have little vegetable food. When he settled among them he was embarrassed by their demands upon his hospitality. Policy dictated that he offer them food on all occasions but there was every prospect that his stores would be rapidly depleted. The situation was relieved by a simple device. It was only necessary to salt the food moderately—merely to his own liking—to deter his visitors from making inroads upon it. The requirements of courtesy were satisfied and the provisions were conserved.

When a sample of food is burned as completely as possible the mineral constituents remain as ash. Chemical analysis of this ash leads to very different findings in the case of different foods. Several acids and bases will always be found. We will consider only the occurrence of sodium and potassium. The ratio between the quantities of these two bases is widely varied, though in the great majority of instances potassium is the more abundant. In animal foods the disparity is not marked but in most vegetable substances it is striking. For example, the proportion of potassium to sodium in meat (veal) is 4 to 1, while in potato it is more than 30 to 1.

Can we recognize a causal connection between the excess of potassium in a vegetable diet and the craving for sodium chloride which is attendant on the use of such a diet? Bunge maintains that we can. His explanation has been criticised in detail but is probably valid in its main thesis. The absorption into the blood of a quantity of salts, unlike those normally present there, imposes upon the kidneys the duty of restoring standard conditions. If the chief demand is for the removal of potassium compounds the task will soon be accomplished. But this will not be done without a considerable loss of sodium chloride. It would be remarkable, indeed, if the kidney cells could select all the foreign ions and not occasionally let slip some of the much more numerous native ones.

Bunge was able to demonstrate, upon himself, the fact that an excessive intake of potassium salts does lead to a loss of sodium chloride. He swallowed as much potassium phosphate and citrate as he could tolerate and subsequently excreted all the potassium—equivalent to 18 grams K_2O—but simultaneously eliminated 6 grams of sodium chloride. Such a draft upon the tissues could not be continued indefinitely unless salt were supplied in corresponding amount. Bunge's personal experiment was not an unreasonable one, for it is calculated that when potatoes form the bulk of a man's ration twice as much potassium may be ingested as in this trial.

There is, therefore, no doubt that salt is a necessary addition to diets in which the ratio of potassium to sodium is unusually high. The instinctive craving for it is a marvelous instance of the almost infallible correctness of such impulses. Bunge has recorded the use by an African tribe of the ash of a certain tree as a seasoning for their food. Most kinds of wood reduced to ashes would yield a mixture over rich in potassium which would be a most undesirable adjunct to other articles of vegetable origin. But the tree in favor with these people was the rare exception; its ash contained a most unusual proportion of sodium compounds. It is rather painful to fancy the tedious succession of experiments by which the ancestors of this tribe eliminated various kinds of wood, and pleasant to imagine the satisfaction realized when the fortunate choice was finally made.

SCIENTIFIC AERONAUTIC RESEARCH

DESCRIPTION OF THE NEW AERODYNAMIC LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY WHICH PUTS AEROPLANE DESIGN ON AN ENGINEERING BASIS

BY J. C. HUNSAKER

Air craft have become in the last few years primarily war material, and as such, are designed to meet definite specifications of performance. Five years ago the supreme test of an aëroplane was whether it could fly or whether it could not fly. Now we inquire how fast and how slowly it can fly, what is its rate of climb, useful load, and radius of action? For example, for military uses, armies require a slow endurance machine for strategic scouting which can make raids into the interior of an enemy country. For tactical scouting over the field of battle, where enemy aëroplanes must be evaded, an army requires a scout of great speed but limited radius of action. Such a machine must have speed and climbing ability superior to that of the enemy units. A third type called a "fighting aëroplane" is necesary to drive off enemy scout aëroplanes. Such a machine must combine the greatest practicable speed and climbing rate with the extra weight of an armored body and a machine gun with a gunner. The performance required for such a destroyer is fixed by the probable ability of enemy scouts to elude it. A fourth type of military aëroplane may soon be developed for the purpose of bomb-dropping. Here the designer would be required to produce a machine able to transport great weight over a long distance.

In all the cases mentioned above the entire military value of the aëroplane lies in its performance, and the burden is thrown on the designer to produce a machine to meet all requirements. Just as in naval architecture, the problem is a compromise between the conflicting claims of speed, armor, armament and radius of action.

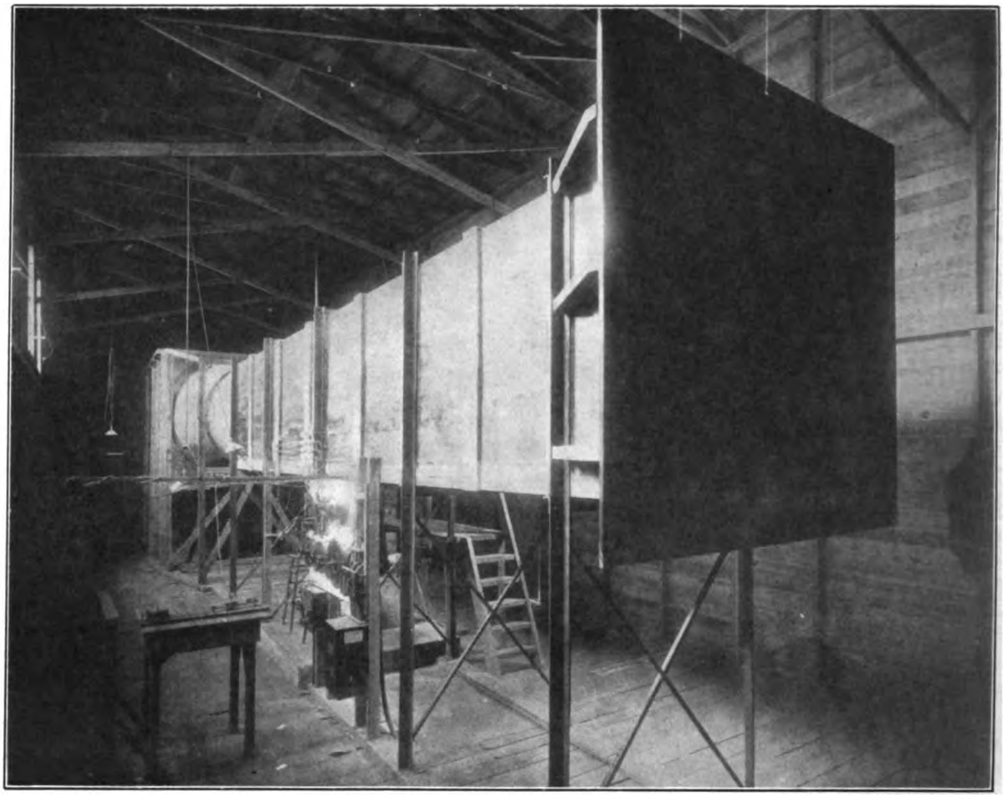
In view of the necessity for designing aëroplanes to possess given qualities, a designer must guarantee performance. A desired type can, of course, always be reached by building a series of machines but this procedure is extremely costly in time and money, and requires a pilot to risk himself in experimental flights on under-powered and unstable machines.

The problem of aëroplane design involves so many variables that it is often impossible to arrange experimental flights so that changes are made in but one variable at a time. The peculiar conduct of an experimental machine may often be blamed on any one of some half dozen features of its design, and as a result the tests lead only to endless discussion.

On the other hand, it is well established that the performance of an aëroplane can be predicted from experiments on a small model, geometrically and dynamically similar. Model tests are easy to conduct and afford the great advantage that radical alterations of the model may be made without loss of time or risk of life. Furthermore, in model testing, the various parts of an aëroplane may be tested separately to determine the effect of each part on the performance of the complete machine.

In naval architecture, a designer has a small model of his ship towed in an experimental model basin. From the resistance of the model, he can estimate the resistance of his ship and so guarantee its speed for given power.

For purposes of aëroplane or air ship design, it is possible to tow models in air in a similar manner. However, in aëronautics the problem is extremely complex since in flight, motion is possible



Suction end of wind tunnel

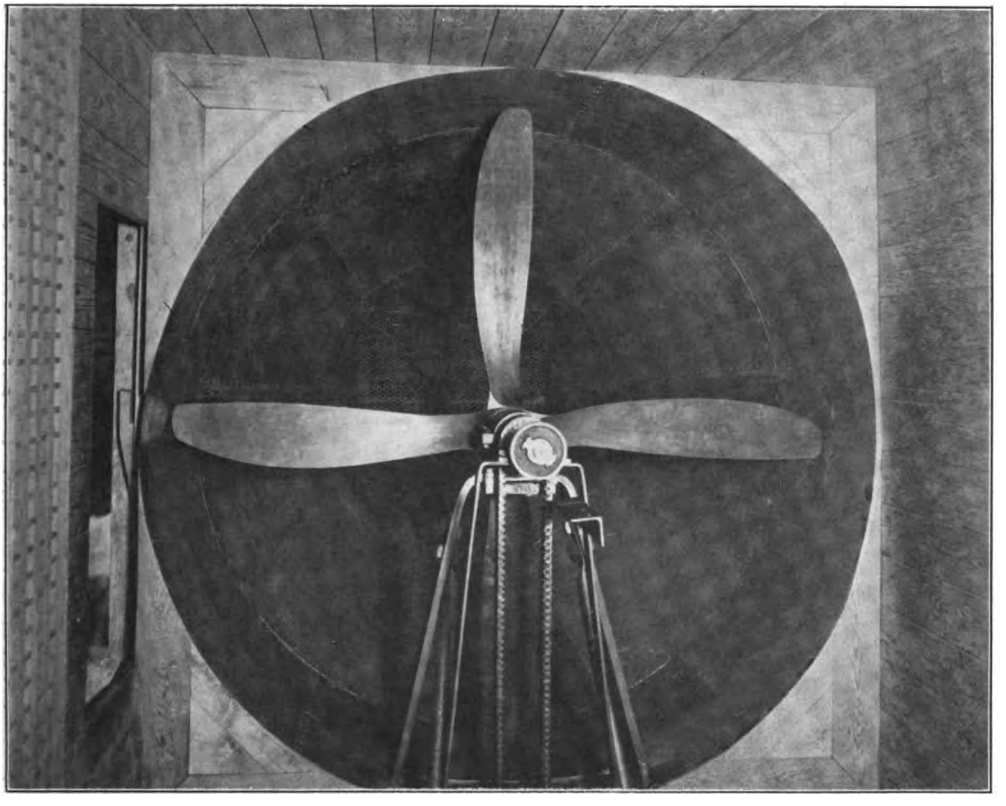
along the three axes in space, as well as rotations about any of them. In general, the effect of the air on a solid object moving through it requires the measurement of three forces and three couples corresponding to the three axes of space.

Towing experiments become mechanically difficult to arrange, and in view of the high speeds required in aëronautics a long building like a rope walk is necessary. Such tests have been made at the Kiel Navy Yard in Germany and at the University of Paris. At the latter institution a dynamometer car running along a track carries objects under test mounted on a weighing mechanism. The tests are conducted in the open air and are subject to error due to gusty winds.

If it be accepted that aërodynamic forces depend on the relative motion of air and object under test, it is immaterial whether the object be towed in still air at a given velocity, or held stationary in a uniform current of air of the same velocity. The use of an artificial wind is the "wind tunnel" method, which has come into general use abroad. The doctrine of relative motion is fundamental in mechanics, and discrepancies between results of tests made by the two methods may be ascribed to the probability of errors due to the influence of the car and wind gusts in the towing method, and to irregularity in the flow of air in the wind tunnel method.

The validity of wind tunnel tests depends upon the uniformity of flow of the air. The production of a current of air that shall be constant in velocity, both in time and space, is a difficult problem.

When it was decided to build a wind tunnel at the Massachusetts Institute



Propeller for wind tunnel

of Technology for use by students in aëronautical engineering, a study was made of the most successful wind tunnels abroad. The conclusion was reached that the staff of the National Physical Laboratory, Teddington, England, had developed a wind tunnel of convenient form and of a high degree of uniformity of flow. This tunnel was the result of a methodical series of experiments with wind tunnels of various forms, in which the following conclusions were reached:

1. Models should be placed in the suction stream leading to a fan where turbulence is least.

2. A four-bladed aëroplane propeller of low pitch gives a more steady flow than the ordinary propeller fan used in ventilation work, and a much steadier flow than any blower of centrifugal type.

3. The wind tunnel should be completely housed to avoid the effect of outside wind gusts.

4. Air from the propeller should be discharged into a perforated box of great volume, to damp out turbulence, and to return the air at low velocity to the room.

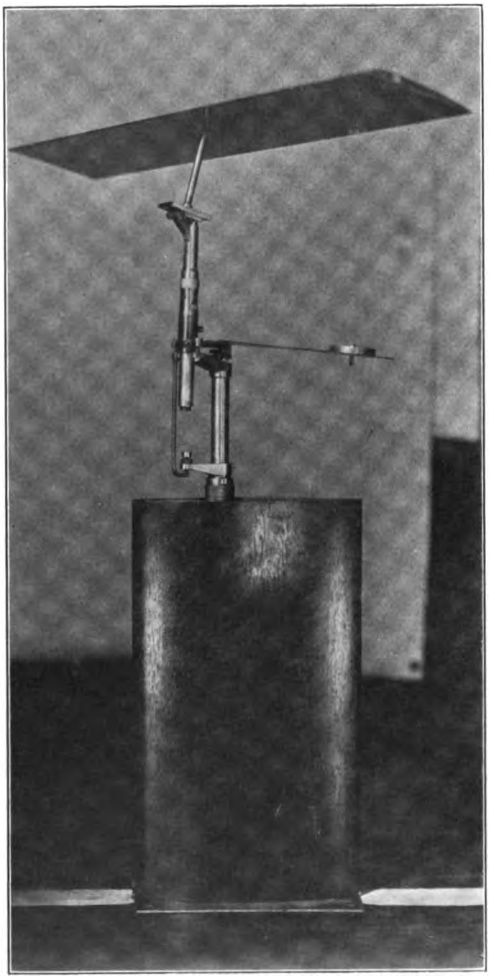
5. The room through which air returns from the perforated box to the suction nozzle should be at least twenty times the sectional area of the tunnel.

The wind tunnel of the Massachusetts Institute of Technology was built in accordance with the English plans with the exception of several changes of an engineering nature introduced with a view to a more economical use of power. An increase of the maximum wind speed from 34 to 40 miles per hour was thus obtained.

Upon completion of the tunnel an investigation was made of the steadiness

of flow. It appeared that the variation of velocity with time and from point to point of the cross section was not more than one per cent.

The wind tunnel proper is a square trunk 16 square feet in section and 53 feet in length. Air is drawn through an



Wing model in position for test

entrance nozzle and through the tunnel by a propeller driven by a 10 H. P. motor. Models under test are mounted in the middle of the tunnel on the arm of a delicate balance.

The air entering the mouth passes through a honeycomb made up of a nest of three-inch metal conduit pipes. This honeycomb has an important effect in straightening out the flow and in preventing swirl.

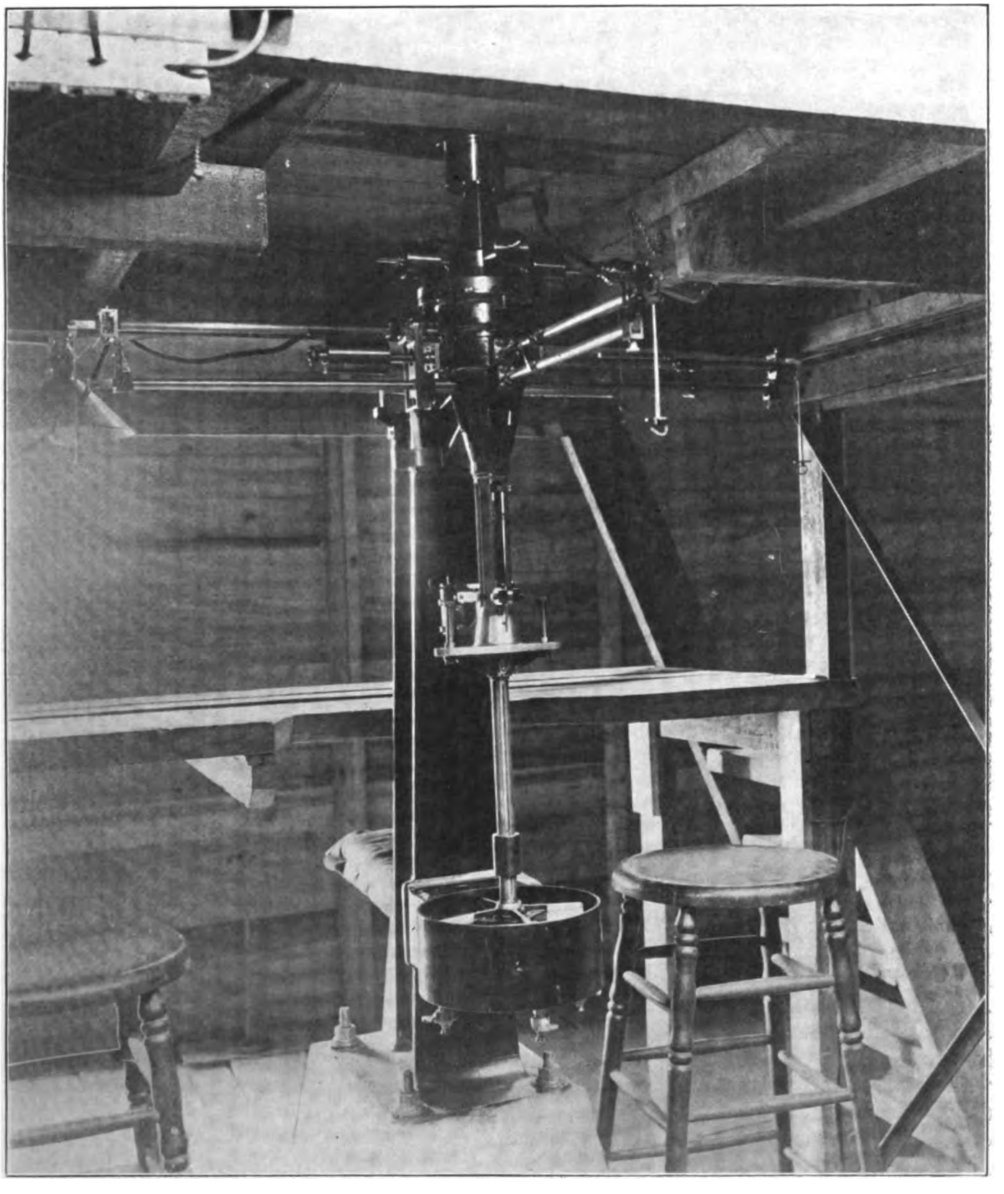
Passing through the square trunk and past the model under test, the air is drawn past a star-shaped longitudinal baffle into an expanding cone. This cone expands in 11 feet to a diameter of 7 feet. The velocity of the air is reduced in passing through the cone and has its pressure increased in accordance with a well-known hydraulic principle.

The propeller is made of black walnut with four blades. It works at the large end of the cone and discharges into the diffusor. The latter is built of wood grating with holes closely spaced except on the side facing the propeller which has no openings. The propeller race is stopped by this wall, the velocity of the air destroyed and the pressure raised. The air then escapes through the holes in the diffusor into the room. The current is thus turned through 90 degrees and brought nearly to rest.

The propeller was designed on the Drzwiecki system, which assumes that each blade section is an aëroplane wing moving through the air in a spiral path. In order to keep down turbulence, a very low pitch and a broad blade were used. To gain efficiency the blades were made thin and, therefore, weak. To prevent fluttering of the blades, the blade sections were so arranged that the centers of pressure of all sections lie on a radial line drawn on the face of the blade. This artifice seems to have prevented the howling at high speeds commonly found with thin blades.

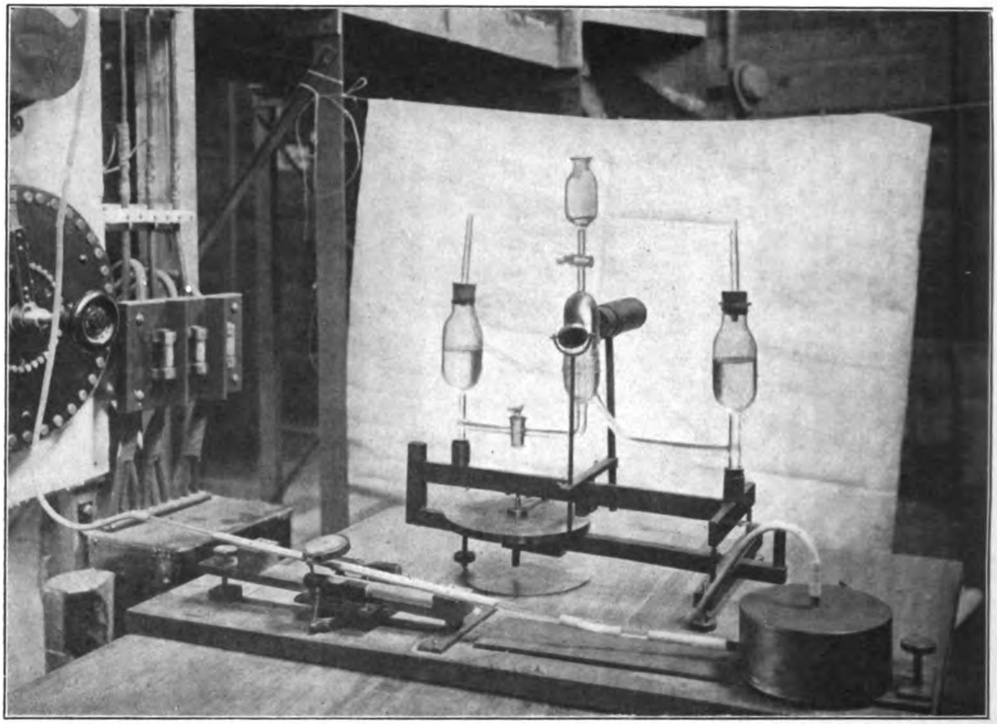
The propeller is driven by a "silent" chain from a 10 H. P. inter pole direct current motor. The propeller and motor are mounted on a bracket structure fixed to a concrete block and are hence independent of the alignment of the tunnel. Vibration of the motor or propeller cannot be transmitted to the tunnel as there is no connection.

In order to maintain a steady current of air, the fan must run at constant revolutions per minute, but in order to allow a fine adjustment to obtain and hold any



Aërodynamic Balance

speed, a direct current motor is necessary. To run a direct current motor at constant speed requires a steady voltage. Such is not available. Consequently the following procedure was adopted. A 15 H. P. induction motor is connected to the alternating current power mains of the Cambridge Electric Company. This induction motor is coupled directly to a 12 H. P. direct current generator. The generator supplies current to the motor which turns the propeller. For constant wind speed, the load is constant and hence the induction motor will turn over



Chattock micro-manometer (above), Krell manometer (below)

at constant speed since its slip is a function of load. Variation of voltage in the city mains has small effect on the speed of the induction motor, which runs at a speed proportional to the frequency of the supply current. The generator being turned at constant speed generates constant voltage, and the propeller then runs at constant speed. Due to slow changes in frequency it is necessary to provide variable resistance in the direct current motor field, by the use of which the wind speed can be corrected from time to time.

Any wind can be made of velocity between 3 and 40 miles per hour.

The model of complete aëroplane, wing, tail, body or other part is mounted on an aërodynamic balance constructed from the plans of the National Physical Laboratory, England. This balance consists of a cast pillar mounted on an independent concrete block, and the balance proper. The latter is made up of three arms mutually at right angles representing the axes of coördinates in space about and along which couples and forces are to be measured. The model is mounted on the upper end of the vertical arm which projects through an oil seal in the bottom of the tunnel.

The entire upper part of the balance rests on a steel point, bearing in a steel cone supported by the cast iron pillar.

The balance is normally free to rock about its pivot in any direction. When wind blows on a model, the components of the force exerted are measured by hanging weights on the two horizontal arms to hold the model in position.

The balance is also free to rotate about a vertical axis through its pivot. The moment producing this rotation is balanced by a calibrated torsion wire.

Special attachments permit the measurement of the force in the vertical axis and moments about the two horizontal axes.

The three forces and three couples acting on any model placed in any attitude

to the wind can be studied at leisure. The balance is precise to one per cent.

Velocity is measured by means of a Pitot tube which was calibrated on the whirling arm at Teddington. The Pitot tube pressures are read on a Chattock liquid micro-manometer. Velocity readings are precise to one half of one per cent.

Tests have been made to determine the lift and resistance of a model aëroplane wing which had previously been tested in England. The results are in excellent agreement and indicate that the English tunnel and balance have lost none of their precision in the rather extensive alterations that have been made here.

The wind tunnel has been in operation since July, 1914, and has been used for comparison of Pitot tubes, determination of the aërodynamic coefficients for a number of wings, bodies, and miscellaneous objects, for thesis work on aëroplane stability and by students in connection with problems arising in the course of aëroplane design.

It is hoped that in following up design by wind tunnel testing, aëroplane design is being placed on a rational engineering basis.

MOSQUITOES NOT ALWAYS RESPONSIBLE

A PAPER by Dr. Charles S. Braddock of New York, late chief medical inspector of the Royal Siamese Government, published in the *New York Medical Journal* has attracted a great deal of attention lately by presenting evidence that mosquitoes are not the only means by which malaria is transmitted. Dr. Braddock points out that, while care was taken to show that water, clothing, and association were incapable of transmitting yellow fever, the studies on malaria merely demonstrated that mosquitoes transmit the disease and failed to show that it was not also transmitted by water or by direct infection from the soil. The Italian scientists in their classical studies lived in a house with a floor raised above the ground and drank either wine or boiled water. Dr. Braddock brings forward numerous instances from his experience in Siam, French Indo-China and the Malay States and from his observations when a lieutenant of the line in the United States, in the United States Navy and when serving in Cuba and Hayti which tend to show that in a country known to be malarial and among men who were equally protected from mosquitoes those who drank raw water or slept on the ground contracted the disease, while those who drank boiled water and slept on cots raised above the ground remained well. He also cites the case of a section of Siam which is notorious as a hotbed of malaria but in which there are no mosquitoes.

The general experience and opinion has too much weight to be readily upset, but the idea may set on foot some interesting studies on the subject. E. A. I.

PLUMB LINE VAGARIES

THE fact that de Filippi in his exploration work in Kashmir is paying a great deal of attention to gravimetrical observations calls attention to the unusual deflection of the plumb line in northern Hindustan. This has been theme for discussion in a number of the Professional Papers of the Indian Survey, and a sketch of the status of the subject is presented in a recent geographical journal. A high northerly deflection has been observed to reach its maximum along the southern edge of the Himalaya range, decreasing on both sides. Colonel Burrard, in 1912, suggested a deep rift in lower layers of the earth's crust, filled in the course of ages by material of less specific gravity than the rock formations on either side, and he further suggested an origin for the rift coeval with the uplifting of the mountains. The idea has not been a popular one with geologists who claim that such a rift, a wedge twenty miles deep and only five in width at the surface, is anomalous. The Indian geologists suggest instead that south of the great fault that marks the Himalayan margin there is an immense depression which has been filled with the alluvium that now constitutes the plain of the Ganges and this is of much lower specific gravity than the mountain rocks.

BATESON'S THEORY OF EVOLUTION

THE ORIGINAL MICROSCOPIC EGG CONTAINED THE ESSENCE OF EVERY DEVELOPMENT IN LIVING THINGS — SUDDEN EVOLUTIONARY VARIATIONS SUBJECT OF DISCUSSION

BY HERVEY W. SHIMER

THERE has been much discussion of the address on Heredity delivered by Dr. William Bateson this past summer in Australia in his office of president of the British Association for the Advancement of Science. At first reading it seems subversive of nearly all of the structure of evolutionary theory that has been slowly building since Darwin's time. In reality, however, it may be regarded merely as a fuller application than has hitherto been attempted of the Mendelian or analytical method of study to the facts of organic life and heredity. The result is that while we still look to Darwin as unquestionably the first to provide a body of facts showing the variability of all living things, we must disagree with him in regarding natural selection as the chief factor in this variation, that is in the origin of species.

Darwin was the first to demonstrate by an immense body of illustrative data the fact that all living things vary, that every animal and plant differs, often in a barely perceptible degree, from every other animal and plant. This he explained as the result of the action of the environment which must of course be different in at least some small measure for every being. Certain characteristics of the organism fit in with the environment favorably, certain others are antagonistic. Those favorable thrive and tend to be reproduced in the succeeding generation, and are thus perpetuated; those unfavorable are thwarted and suppressed or if prominently antagonistic to the environment cause the death of the organism and hence die out with its generation. This is the theory of natural selection and to its agency Darwin attributed the fact of variation, and of the origin of species among animals and plants. This, Darwin considered to be the most important method of evolutionary change though he recognized likewise the occurrence of sudden changes later emphasized and elaborated by DeVries in his treatment of the mutation theory. This doctrine of cumulative variation naturally results in a conception of evolution as a slow and a steadily progressive movement; through this, one form is gradually changed into another by the addition of minute characters which have originated in spontaneous variation and have been selected by the environment and thus perpetuated and passed on by heredity to the succeeding generations.

For this conception of evolution Bateson asks us to substitute one that he likens to the unpacking of an original complex. The earliest primordial speck of life contained the whole range of diversity which living things now present or may in the future develop. And variation simply means that certain lines of organic descent emphasized certain of these possible characteristics, leaving the others, and passed them on to their descendants which again selected from those handed on to them. Thus evolution instead of being a process of addition of factors is a process of continual subtraction.

This selection of variations proceeds according to the law of heredity discovered by Mendel whereby certain characters of the organism are dominant, *i. e.*, in control and appear in the lifetime of the individual, and others are latent and do not appear although they may be passed on to their descendants.

And Bateson asks whether, if it seem absurd that the earliest form of protoplasm could have contained complexity

enough to produce the divers forms of life, it is any easier to imagine that these powers could have been conveyed by additions from without.

To the possible variations given to an animal or plant by this process of subtraction from the original complex is added the wide range of possibilities due to crossing, whereby the organism gets the possibilities of the two complexes which are its parents.

It would seem as though this conception of evolution as a passage from the complex to the more and more simple, in which the organism specializes in certain characters and drops off certain other possible characters might be likened to the manner of our social evolution. In pioneer days every man is a complex of industrial possibilities—he is his own carpenter, blacksmith, cobbler and physician. In the course of time his descendants specialize more and more, each adopting some one line of industry and leaving behind the other possible activities. Emphasis on some one speciality seems to be the necessity in evolution.

It would, in short, seem that Bateson asks us to consider two main theses:

First, while it can never be questioned that Darwin was the first to provide a body of facts demonstrating the variability of living things, yet we must come to the conviction that his principle of natural selection cannot have been the chief factor in the delimiting of the species of animals and plants. It is asked that we consider that this variation has rather resulted from the fact that to each species has fallen a different set of characters in the unpacking of the original, all-containing ancestral protoplasm—that to each succeeding generation falls a slightly differing set of characters according to the Mendelian law of inheritance.

And in the second place and as a natural consequence of this different evolutionary procedure, we must think of evolution not as slow and cumulative by the gradual accretion of minute variations but as mutational. That is, while according to the Mendelian law, an individual may so closely resemble its parents as to be barely distinguishable, yet the operation of this same law permits of possible sudden deviations whereby a character, heretofore passed down the line as latent, may suddenly appear when some other character which has inhibited it, is removed.

The evolution of Bateson is an evolution of continual subtraction and of sudden variations. Evolution occurs by sudden changes alone, never by gradual variation.

We cannot doubt that evolution occurs—that every organism now on this earth differs from every other organism either of the present or of the past. But it is the question of how they come to be different that is still the subject of theory and controversy.

CASEIN FOR THE TOILET

While the original cold cream may have been made of true cream, the formula in the United States Pharmacopeia of the present day shows that it is a mixture of spermaceti or stearic acid with bees' wax and oil of almonds with a little borax added to aid in keeping the mixture homogeneous. Many of the modern massage creams, especially those advertised as greaseless, have as their most important constituent casein, the substance precipitated from buttermilk. Truly it is a remarkable substance which may be used with equal success for cheese, buttons, billiard balls or face cream.

E. A. I.

BLASTING WITH LIQUID OXYGEN

By a recently discovered method, it is thought that a practical way has been found for using liquid oxygen in blasting. Bags filled with a special form of lamp black are soaked in liquid oxygen a few minutes just before being needed. They can be detonated with the force of dynamite. There is no danger from a misfire, as the oxygen will evaporate in a short time if not exploded soon after being soaked in liquid oxygen.

SOME INSECT-BORNE DISEASES

"A fly and a flea and a skeeter and a louse
All lived together in a very dirty house.
The fly spread typhoid and the louse spread typhus, too,
And the people in that house were a very sickly crew."

The fact that this doggerel with its additional verses has been so widely copied bears witness to the general appreciation of the relation of insects to disease. If the public could be taught to act in line with its knowledge much would be accomplished in the safeguarding of the public health. The knowledge of the relation of flies and mosquitoes to disease is too general to require additional comment in an article whose purpose is to point out the less commonly known relations between insects and disease.

Bacteriologists, protozoölogists, and entomologists are coöperating today in an attempt to demonstrate further relations between insects and certain diseases of which the mode of transmission remains obscure. The recent outbreak of bubonic plague in New Orleans attracts our attention first to this disease. It has been known for several years that the rat flea is the chief agent in the transmission of plague, but the exact means by which infection takes place has been uncertain. The flea is known to imbibe the bacillus which causes plague when it sucks the blood of an infected animal, but how he infects the next victim remained a question. Among the methods suggested have been the ingestion of infected fleas by animals, simple mechanical transmission by the flea's proboscis, infection of the flea's salivary glands as in the case of the mosquito and malaria, and the rubbing of the infected feces of the flea into a wound caused by the bite or otherwise. Recently a commission of British investigators has made an intensive study of the subject and arrived at the following conclusion. The feces of the flea may transmit plague but contain relatively few bacteria and soon dry up, so that this method is uncommon. When a flea has fed on infected blood a rapid development of the bacilli takes place in the intercellular recesses of the proventriculus and this development proceeds to such an extent as to occlude the alimentary canal and prevent the entrance of additional blood to the stomach. The flea retains his appetite, however, and since his pumping device is in the pharynx is still able to suck blood, but the obstructing mass of bacteria prevents the blood from entering the stomach and consequently it regurgitates from the infected esophagus into the wound upon the cessation of sucking.

The flea may not starve as a result of this trouble, as the alimentary canal may later become open, but if the season is hot he may dry up before he can get any liquid. This is said to account for the fact that epidemics of plague in India are confined to the cool and moist season and are terminated by the onset of hot weather.

Leprosy is another disease of foreign origin found occasionally in the United States. It is caused by the *Bacillus lepræ*, an organism similar to the bacillus of tuberculosis, but the mode of transmission is unknown. Men have been known to live among lepers for years before becoming infected, but in other cases the transmission seems to take place almost immediately. Various insects have, from time to time, been suspected of carrying the disease but the most recent studies point to the head louse, *Pediculus capitis*, as the most probable agent, though the experiments have not yet been completed.

Typhus fever, known also as Brill's disease and in Mexico as tarbardillo, has decreased in prevalence with the spread of civilization and, except for sporadic cases, is now found only in overcrowded, filthy or unhygienic surroundings. Although the infective agent is apparently too large to pass through a Berkfeld filter it has not yet been identified, though recently a spirochete has been found to be present in many of the cases. It has been definitely shown that the head louse, *Pediculus capitis*, and the body louse, *Pediculus vestimenti*, are capable of trans-

mitting the disease and the flea is under suspicion, although lice appear to be the chief agent.

Relapsing fever has not been known in this country since the epidemic in New York and Philadelphia in 1869. It also is associated with insanitary conditions and is known to be transmitted by certain ticks, while various biting insects are suspected.

The cause of pellagra has been a subject for study for many years and it is now being investigated in various parts of the world. The buffalo gnat, *Simulium*, and other biting insects, such as the stable fly, *Stomoxys*, are being studied as possible carriers.

The bedbug is so generally disliked that attempts are continually being made to attach to it the stigma of being a disease carrier. Almost all infectious diseases have been charged to it at times but among the most common are relapsing fever, kala azar, tuberculosis, leprosy, typhoid, and syphilis. By its habits of biting and its association with humans it is fitted to carry disease, though it is not naturally associated with filth and lives comfortably in the cleanest surroundings. In this country, at least, it is quite certainly of no importance as a disease carrier, and as an index of decency and cleanliness it will probably rank far below the house fly when public opinion replaces prejudice by judgment. E. A. I.

RELATION OF TEETH AND EYES

A COMPARISON of the distance between the visible part of the eye lobes and the different development of the teeth in the human race, and in some of the mammals has thus far attracted little attention. It is apparent that where the carnivorous teeth are more prominent, as in cats and dogs, the eyes are a trifle farther apart than in the human race. In the rodents, such as rats, squirrels and beavers, the ocular lens is perceptibly placed on the side of the cranium. In the ruminants as well as a large number of other mammals with big molars, such as the horse, and so forth, up to the elephant, the eyes are separated in proportion to the size of the skull, being twice as much or more the distance apart as in the human genus.

It is not known whether or not the growth of the teeth appears in a certain order among the fishes, but with a few exceptions, as in the flounder, the eyes are placed one on each side of the compressed skull. This arrangement is almost similar to that of most birds, which lack dental apparatus if we exclude the serration of the bill in some of the parrot species. MAGNUS WESTERGREN.

BOMB-CARRYING DIRIGIBLES

IN VIEW of the possibility of offensive operations by Zeppelin airships, it may be of interest to observe that such a ship with full crew and fuel for a 1,300-mile trip may carry in addition to its usual ballast 1,600 pounds of bombs, and with fuel for an 800-mile trip 4,300 pounds of bombs. Using 200 pounds aërial torpedoes this allows from 8 to 20 units for each ship.

The striking velocity of such a bomb dropped from an altitude of 3,000 feet is 400 feet per second, and from 6,000 feet, 450 feet per second. This compares with a velocity of 2,000 feet per second for a projectile fired from a rifled gun and explains the lack of penetration of such aërial torpedoes. J. C. H.

ANTI-TYPHOID INOCULATION

THE value of the anti-typhoid inoculation is clearly shown by results in the United States army. Previous to the introduction of compulsory inoculation upon enlistment there was an average of 536 cases and 37 deaths each year. Last year, on the contrary, there were three cases and no deaths and two of these cases were men who had in some way escaped the inoculation. In no case of inoculation was there any record of any harm resulting from it. In the Spanish-American war one fifth of the American army contracted typhoid and 86 per cent. of the deaths among our soldiers in the war was caused by this disease.

E. A. I.

EQUILIBRIUM OF THE BODY

The position of the eyes in the fishes and birds indicates that their area of vision without moving the head must be considerably larger than ours, and their sense of equilibrium therefore different. The swimming act is performed by the pectoral fins and telson, while the dorsal and ventral fins regulate the balance of the body, which is to right or left, similar to that of the birds. That the balance is to right or left can be observed with especial ease in the sparrow, which comes in flocks, while on the ground, rushing or fighting for food, the wings are not always entirely extended; frequently one wing is almost resting on the chest for an instant while its mate is stretched to its full length.

In the human body the equilibrium is kept up somewhat differently, being more of a pendulum-like motion, to and fro, when walking on smooth, level ground, the sacrum describes a continuous horizontal wave line, and if a disturbance of balance occurs, the body usually falls forward, seldom to one side.

The oscillaria in the fishes and a few other marine animals can be regarded as annunciators which tell that something is passing outside. Whether the osseous labyrinth in our own ear is of the same character, or not, or whether it is merely an apparatus to aid in preserving equilibrium, is not known with certainty. Neither do we know whether we really see objects in their right position, or only seem to do so through habit, for they must be reflected upside down on the posterior part of the crystal lens of our eye.

Judging from the way pigeons, especially, tip their heads to one side to see where food is thrown on the ground, some lack in their forward vision is indicated and it would therefore seem that seeing the tips of both wings in the same sidewise glance were of more importance than direct forward vision. This ability to see both sides at once is an advantage which aviators do not possess.

Above a flat country, and an altitude of 10,000 feet, or more, the horizon is beneath the aviator and therefore his feelings about the right position of his aëroplane are lessened. Then, too, not passing any object, and being continually met by a strong wind, the airship seems to be standing perfectly still, and this produces a sleepy monotonousness which tends to make the aviator not always on his guard.

MAGNUS WESTERGREN.

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The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

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STATUS OF THE TIN MINING INDUSTRY

THE UNITED STATES USES NEARLY HALF OF THE WORLD'S PRODUCTION OF THIS IMPORTANT METAL AND MINES PRACTICALLY NONE

BY WALDEMAR LINDGREN

SIX thousand years ago the Egyptian artisans of the fourth dynasty fashioned implements of bronze obtained by melting tin and copper together. Discoveries in the tombs of the eighteenth dynasty and excavations in the ancient city of Knossos on the island of Crete tell a similar story of industries flourishing 1500 to 2000 B.C. except that the weapons and ornaments are wrought with far greater skill. The history of tin thus goes back to the remotest antiquity. The records of most peoples tell us in fact of an early period in which an alloy of copper and tin was the principal metal used.

Through long centuries tin has been one of the most useful metals employed by man in his struggle towards civilization. Although, even at the present time, the production of tin does not approach that of iron, copper, lead and zinc, the metal still remains in a prominent industrial position. Its history is full of interesting features with sharp changes in the sources of production, in price and in practical use.

The metals occurring native, like gold and silver, or easily reduced from their ores, like tin and copper, were those first used by the races of antiquity. Copper, gold and silver occur in many countries, but tin is curiously and irregularly distributed. We know of no deposits of importance in southeastern Europe and adjacent parts of Asia. Most of the tin used in antiquity is said to have come from the "Cassiterides" or Tin Islands* whence it was brought out first by the Phœnicians, those early traders and explorers, at least as far back as twelve centuries B.C. Some of the metal no doubt came from the mines in Spain. How the ore was discovered and who first succeeded in smelting tin from it we do not know. Beyond doubt these "Tin Islands" were the Scilly Islands and adjoining parts of Cornwall. After some centuries the Phœnicians had to abandon their monopoly of the metal, and the deposits were worked by Greek and Roman miners.

Cornwall for a long time remained the one important source of tin, but later on, certainly in the sixteenth century, very similar deposits of tin ore were found in the Ore Mountains of Saxony. Altenberg, Zinnwald and other places furnished most of the tin needed by the Tuetonic races.

Compared with conditions today this mining proceeded upon an insignificant

* "Kassiteros," is the Greek word for tin. In Sanskrit it is "Kastira," in Arabic "Kasdir."

scale. It is estimated that the average annual production of tin in the thirteenth century was only about 300 tons. In the eighteenth century the same figure had risen to about 2,600 tons. This does not, however, represent the world's production for even at the earlier date mentioned tin was produced in China and bronzes were manufactured there but the output can hardly have been more than a few hundred tons per annum.

The next discovery of importance was made in the eighteenth century in the far East Indies, at localities probably long known by the natives, on the islands of Bangka and Billiton now owned by Holland, and in the Malay Peninsula, now known as the Federated Malay States. The production from these new fields soon entirely overshadowed the old fields of Cornwall and Saxony in which production, however, continued on a smaller scale. Even now about 5,000 tons of tin are annually recovered from the mines of Cornwall some of which have reached a depth of 3,000 feet.

The new continents opened by the white race were carefully searched by prospectors for tin as that metal began to assume an increased industrial importance. Every state of Australia was found to contain tin deposits in part associated with gold, and about 5,000 tons are now obtained from that region. Smaller deposits were opened in South Africa and recently Nigeria in Central Africa has entered the ranks of the producers with some 3,000 tons per annum. China has reopened her ancient tin mines of the Yunnan Province, and some thousand tons are added annually from that quarter.

Important as many of these sources are they seem insignificant in comparison with the great production from the Malay Peninsula which every year yields from 50,000 to 60,000 tons of the metal.

Far distant from the tropical jungles of the East Indies is the Bolivian district, where ore is mined on the high Plateau of the Andes in a wintry climate and at elevations of 16,000 feet. The Bolivian tin, known to some extent by the old Spanish miners, has recently acquired great importance, and the production is steadily rising. In 1913 about 28,000 tons were produced.

The singular and capricious distribution of tin ores has already been referred to. The United States is particularly unfortunate in this respect for in spite of careful prospecting no tin deposits of any consequence have yet been discovered within its domains. A few tons are produced from the bleak shores of Cape York Peninsula in Alaska; a little more comes from the Black Hills in South Dakota, and from the Appalachian Mountains in the Carolinas.

The total production of the world is for various reasons very difficult to estimate with exactness, but it has been steadily rising. Approximately 114,000 metric tons was the production in the world in 1908; in 1913 this had increased to about 125,000 tons.

The principal, and almost the only ore of tin, is the oxide. It forms a brown and inconspicuous mineral of great hardness, called cassiterite. This mineral is extremely resistant to the influence of weathering, and thus it easily accumulates in gravel beds lying below the outcrops of the veins. The only other mineral of importance is a complex sulphide of tin, copper and iron, which occurs in Bolivia and a few other places. The tin deposits form veins along rock fractures, or in crushed masses of rock, and some deposits have been followed by mining to a depth of several thousand feet. In such veins the cassiterite is accompanied by quartz and by a number of rare and characteristic minerals like wolframite containing tungsten, topaz containing fluorine, and tourmaline containing boron. Geologists hold that such tin-bearing deposits have been formed at high temperatures by vapors and solutions accompanying the intrusion of granite far below the surface of the earth. The veins, as they appear now, have been exposed by the gradual wearing down of the surface by erosion.

To ancient man, mining in hard rocks was a difficult problem, but the heavy tin mineral which occurred in abundance in some gravels, for instance, in Corn-

wall and in Saxony was easily recognized, and must have attracted attention at an early date. The cassiterite, or tin-stone is reduced to metal by charcoal in a hot fire, and we may easily imagine the accidental discovery of this reduction process.

For many years the tin-stone contained in gravels furnished a large part of the output of the world. As such beds can be worked cheaply a content of about two pounds per cubic yard of gravel may be sufficient for a profitable enterprise. At the present time the great deposits in the Federated Malay States and adjacent islands are almost wholly gravel beds, which are washed like gold placers for the recovery of the tin-stone. The prospectors are in large part Chinese, and until recently the work has been carried on in a primitive way. Now, however, hydraulic mining, that is, by a stream of water under pressure, and dredge mining, have been introduced into these regions.

On the other hand, the Bolivian deposits occur as veins, in slate and sandstone, and have been worked to a depth of 1,500 feet without showing noticeable impoverishment. The ore mined by the smaller concerns is rich, containing 10 per cent. or more of tin, but recently some enterprises have been started on a larger scale and on the basis of 3 per cent. ore. A peculiar feature is that silver, elsewhere absent from tin veins, often occurs in the ores. The grade of ore in the deep mines of Cornwall is much lower; it is said 1 to 1.5 per cent.

The use of tin in bronze for many purposes, such as implements, statues and ornaments, has already been mentioned. In medieval times bronze found an extensive use for church bells and later on, in the eighteenth century, tin mining received a further impetus by the use of bronze for a far less commendable purpose, that is, for the manufacture of cannons. The malleability of tin is an especially valuable property. Tin foil has been used for many hundred years, and no small amount of the metal enters into the production of this commodity. A still larger quantity is used for soldering and for various alloys, many of them easily fusible, and some used for bearings, etc. The low fusion point of tin (449° F.) is thus another property which commends the metal for manifold purposes in the foundry. Within the last hundred years many uses have been discovered for various tin compounds. Of these the chloride is particularly useful for many industrial processes.

All these uses are, however, subordinate, and if there were no demand outside of them the production of the metal would certainly not have risen to its present level. For the recent great consumption of tin the modest tin can is primarily responsible. Eighty thousand tons of the metal is annually required for the manufacture of these receptacles of sheet iron, covered by a thin coating of tin. In the last fifty years the demand for tin cans has risen enormously with the development of the preserving industry for provisions of all kinds, and last, though not least, for the shipment of petroleum all over the world.

Thus it happens that the United States, though leading in the canning industry, finds itself severely handicapped by a deplorable lack of tin deposits and is, broadly speaking, wholly dependent upon the production of the Federated Malay States and Bolivia. A protective tariff has made it possible to transfer the tin plate industry to the United States. We annually import about 50,000 short tons of tin as ingots. The figures vary sharply and suddenly. In 1907 and 1908, for instance, only 41,000 tons were imported, while a maximum was reached in 1912 when the importation amounted to 58,000 tons.

The price of tin has been subject to striking variations: a great deal of speculation and short selling is carried on, and the fluctuations are often extremely violent. The market price has varied from 13 cents per pound in 1896 to a maximum of 54 in 1913. During the last few years the price per pound in New York has varied between 25 and 50 cents. In January, 1908, the price was, for instance, 27 cents, while in January, 1913, it had advanced to 50 cents. The war which broke out in August, 1914, had an important influence on the market, but the price has

not increased greatly, but is, on the contrary, less than before. In the beginning of 1914 the price reached 40 cents, but later on dropped to 31 cents; in August there was a sudden rise to 50 cents, but in the last four months of the year the average price was only 31 to 33.5 cents. There was naturally, at first, a fear of shortage by the closing of the lanes of commerce and it will be remembered that one precious cargo of tin was sunk by the German cruiser *Emden* in the Indian Ocean. There is now little fear of the interruption of ocean communication, but instead the great consumption in Germany is suddenly checked, and it is not likely that the price will rise to high figures until we shall have peace once more.

This question of tin is a very serious matter for the United States. One hundred million pounds of tin, equivalent to about $40,000,000, is needed annually and must be purchased from foreign producers. There are no prospects, visible as yet, of domestic production of the metal. This granted, the most important problems relate to (1) control of foreign deposits by Americans; (2) domestic smelting of foreign ores, and (3) possible recovery of tin once used.

The control of the Malayan deposits is difficult and probably would be opposed by the colonial government. These gravel deposits are to the extent of 75 per cent. owned by Chinese firms who are able to carry on the work at very reasonable cost. Nevertheless, it is possible that we would be able to work these gravels to better advantage than the Chinese by the use of the most modern methods. The ownership of the Bolivian deposits is now in the hands of English, German and South American companies. Many attempts have been made by American capitalists to acquire control of these mines, the ores of which are of high grade, but so far these attempts have apparently not met with much success. The prices demanded for the mines are very high, and the costs of mining and reduction are considerable on account of an unfavorable climate and difficult transportation. Nevertheless, it seems probable that control will ultimately be acquired. Under normal conditions all of the Bolivian ore goes to Europe for reduction, one half of it to Germany, and the other half to England.

The larger part of the ores from the Federated Malay States is smelted locally and the tin exported. Therefore, it seemed possible to transfer the smelting of Malay concentrates to the United States, especially as the Standard Oil steamers returning from these parts could carry the ore at low rates. A smelter was accordingly built at Bayonne, N. J., but the tender industry was cruelly nipped in the bud by the Federated Malay States which, under British influence, promptly imposed a prohibitive export tax on concentrates. There seems to be no reason why Bolivian ores should not be brought to New York, via the Panama Canal, and smelted there, but it will be necessary to secure a firm hold on the ore supply before entering on plans for reduction works.

The principles of conservation clearly demand that as much tin as possible should be recovered from scraps and cans. As far as scraps from the manufacture of tinware this is, of course, done. A little more than one quarter, or about 14,000 tons, of the total imports of tin is recovered from scraps by electrolytic methods. The tin cans however, offer a far more serious problem. Their life is short and the tin used in them for coating of the sheet iron is very largely lost. It is easy of course to collect such used cans but the recovery of the tin is difficult and expensive owing to the organic matter and grease usually adhering to the articles. The discovery of a cheap process for the recovery of tin from this source would be highly desirable. Several small plants for this purpose are said to be in operation in England.

Another very important problem relates to possible substitutes for tin. Cans for oil might possibly be made from zinc coated (galvanized) sheet iron and the possibility of aluminum coated cans is perhaps not to be disregarded. Both zinc and aluminum are much cheaper than tin.

It is a long step from the time, thousands of years ago, when the Egyptian

artisans melted their bronzes and shaped their implements from copper and a few precious tons of tin, to the present time, when a hundred thousand tons are used to carry the world's commodities around the world. The importance and complexity of the problem of tin production, as far as the United States is concerned, has been pointed out in the preceding pages. It would seem that the time is ripe for an attempt to change the conditions which, in past years, have been so unfavorable to us.

ELEMENTS WITH SEVERAL ATOMIC WEIGHTS

Scientists of the present generation consider matter to be made up of small particles called molecules. These molecules are themselves composed of smaller bodies to which the name "atom" has been given. The atom has been defined as the smallest particle of an element that enters into combination with other atoms to form molecules.

Now just as the various elementary substances have different weights, so must the atoms of the individual elements have different weights, and it was natural that scientists should seek out a basis upon which to compare the relative weights of atoms. The actual weights of the atoms are of course too small for convenient comparison, and, as a result, the atom of the lightest known element, hydrogen, was arbitrarily chosen as the standard unit, and all the others were expressed in terms of this unit. The atomic weight of an element might, therefore, be defined as the relative weight of the atom compared to the weight of the atom of hydrogen as 1.

It was formerly supposed that each element had one, and only one, atomic weight, but it has been shown by recent investigation that lead from radio-active substances has a different atomic weight from that of the ordinary variety. Strange to relate, however, these different kinds of lead, if different in kind they are, have precisely the same chemical properties. That is, although the element itself may differ in atomic weight according to its source, the salts of the different varieties are identical. It has been suggested that elements, which have the same chemical properties but different atomic weights, such as lead has, should be called isotopes.

Many scientists have long been waiting to be shown that all the eighty odd elements are composed of one, or at least a few simple substances. The new discovery may be a step in this direction.

E. B. S.

TAKING UP THE RECOIL

The quick-firing field gun used by the French and British is equipped with a most ingenious device for taking up the recoil. When it is fired the gun slides along guides on the top of a steel box, called the cradle. Inside of the cradle, and attached to the gun, is a piston, which is driven by the recoil into a cylinder filled with glycerin. The glycerin is forced through narrow channels into a reservoir full of compressed air, which it further compresses. This friction brings the gun to rest after it has recoiled and then the expansion of the compressed air forces the glycerin back into piston and returns the gun to the firing position once more.

A DELICATE INSTRUMENT

In the development of apparatus for the delicate work of measuring the radiation from the stars, which is being carried on by the United States Bureau of Standards, an instrument has been invented which is so sensitive that, in combination with a three-foot reflecting telescope, it will give a galvanometer deflection of one millimeter when exposed to the heat of a lighted candle placed at a distance of fifty-three miles. In order, however, to do much valuable work in stellar spectral energy curves, an instrument must be developed that will be sufficiently sensitive to detect the radiation from a candle placed at a distance of 500 miles away from it.

NEW DISCOVERIES IN OIL REFINING

THREE TIMELY AND ENRICHING DISCOVERIES THAT CONSERVE AN IMPORTANT RESOURCE AND HINT AT THE ORIGIN OF CRUDE PETROLEUM IN THE EARTH

BY ELLWOOD B. SPEAR

Gasoline, naphtha, benzine, kerosene, most of our lubricating oils, vaseline and paraffin, are obtained by distilling crude petroleum. As is well known, this substance is found in enormous quantities in the earth, and the United States and Russia are the chief producers. Twenty years ago kerosene was the most sought for of these products, while we had a surplus of gasoline. With the advent of the internal combustion engine, as a means of power, especially the enormous output of automobiles of recent years, gasoline has become the all-important member of this series. Until a year or so ago the maximum amount of gasoline obtainable from crude petroleum was comparatively small, *i. e.*, less than 7 per cent. The exact amount differed with the different varieties of the crude material. The price was steadily increasing, and it became a serious question whether the internal combustion engine could long be employed in the future as a means of power, because of the high cost of the fuel, gasoline. Happily recent discoveries have changed the entire aspect of the affair. The price of gasoline has greatly decreased and auto owners may breathe easily once more.

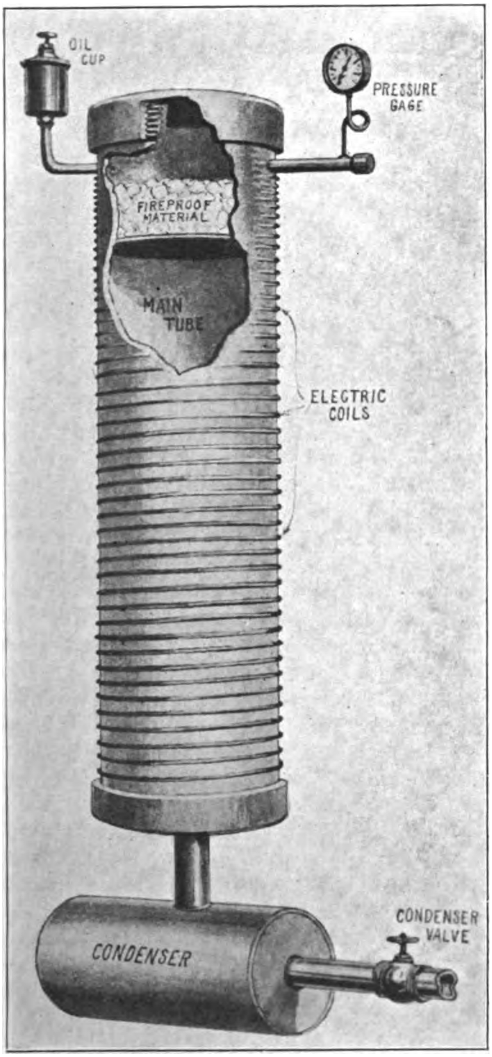
The first of these discoveries, as set forth by the Burton patent, has already proved itself of great commercial value and is at present employed by the Standard Oil Company. Until the introduction of this process crude petroleum was distilled either at atmospheric or under slightly increased pressure. The vapors obtained were suddenly cooled and condensed at the pressure of the air. Herein, however, lay the mistake; for Burton discovered that if the distillation was carried out under pressure and the vapors were condensed also under pressure, the yield of gasoline was increased two to three-fold. It is needless to say that this is of very great importance for the future of the gasoline engine.

Two other startling discoveries, one by Rittman and the other by Snelling, promise to become of enormous importance to our industries. It should be noted, however, that both these discoverers warn us against forming hasty conclusions, such as we have recently been treated to in the newspaper reports of these discoveries. The processes of both Rittman and Snelling are still in the experimental stage, and while they may be feasible in the laboratory, it remains to be proved that they are practicable on a commercial scale.

It has long been noted that crude petroleum, if allowed to fall on hot bricks, was partially broken down into gasoline and other closely allied substances. This process is employed by producers of illuminating gas and is commercially known as "cracking." Rittman has discovered that if this cracking process is carried out where the oil is in the form of a gas and under great pressure, *i. e.*, 500 pounds per square inch, the amount of gasoline obtainable is greatly increased. Nor is this all. Benzol and toluol, the raw materials from which dyes and the most valuable explosives are made, are also formed during the cracking process.

Rittman's laboratory apparatus is shown in figure 1. The oil is allowed to drop from the oil cup upon a heated, fireproof material, as seen in the cut. The gases thus formed pass into the main tube. This is heated by electric coils, and the higher temperature causes an increase in the pressure. The cracking process takes place in the main tube under these conditions. The products are condensed in

the tube at the bottom of the apparatus. (Marked "Condenser" in the cut.)



The experimental apparatus of Dr. Rittman—Courtesy of the *Scientific American*

It is pleasing to note that Rittman's process is to be patented and dedicated to the American people, so that small and independent oil companies may compete with the larger and more wealthy concerns.

Snelling's discovery, if it turns out to be practicable commercially, is even more important than either that of Burton or Rittman. Snelling's experiments indicate that not only is more gasoline obtained when the cracking takes place in the vapor instead of the liquid phase, but also that crude petroleum is a product into which each one of the substances mentioned in the first paragraph of this article may be changed at will. That is to say, after all the gasoline possible has been extracted by the Rittman and Burton processes, the remaining substances, paraffin, vaseline, lubricating oils, etc., may be introduced into Snelling's apparatus and a crude petroleum again formed which differs from the original crude petroleum only in that the artificial product does not contain any clay. This artificial petroleum is again capable of treatment by the Rittman or Burton process and more gasoline can be distilled off. By repeated distillation and "repetrolization," to coin a new term, Snelling has succeeded in changing a very much larger proportion of the total original crude petroleum into gasoline than can be done by the Rittman or Burton process alone.

Snelling's important discovery throws some light on the origin of crude petroleum in the earth's interior. All the above mentioned compounds, gasoline, kerosene, etc., are combinations of hydrogen and carbon. If any one of these compounds is formed in the earth under suitable conditions of temperature and pressure, it will be converted into crude petroleum. It of course remains to be seen whether such a deduction is entirely justifiable or not.

THE GYRO-COMPASS IN THE NAVY

The Sperry gyro-compass, which was described by Mr. Sperry in the first issue of Science Conspectus five years ago, when it was in an experimental state, has now been placed on twenty battleships, one armored cruiser and fifteen submarines of the United States navy. It has been decided to install master gyro-compasses in duplicate on all battleships of the *Delaware* class and later. Special instruction is given to officers and men who have the care of these compasses.

THE ORIGIN OF PEARLS

In an article in *The Popular Science Monthly* a year or two ago Professor Edwards of the University of Southern California had an article on "The Abalones of California." A paragraph in the article on pearls is interesting:

"The origin of pearls has been a matter for speculation during many centuries. As related in ancient folklore, the pearl oyster, rising to the surface of the sea in the early morning, opens wide the valves of its shell, so that dewdrops may fall within. Under the influence of the air and warm sunshine lustrous pearls develop from these glistening drops of dew. The pearls are white when the weather is fair, but dark if it is cloudy. This belief was held from the first to the fifteenth century, when the theory was advanced that the eggs of the pearl oyster serve as nuclei for pearls.

"About the middle of the sixteenth century Rondelet concluded that pearls form from diseased concretions, and then, in 1600, Anselmus de Boot demonstrated that they are made of the same substance as the shell. Réaumur, in 1717, showed by aid of the microscope that the pearl is composed of concentric layers of nacre, which we now know serve as minute prisms to split up the white light into the rainbow tints so beautiful when reflected from the surface of the pearl. In the middle of the nineteenth century from an investigation of the freshwater mussels of Turin Lake, Filippe proved that the stimulus for pearl formation in that species is a trematode worm.

"Other naturalists, Küchenmeister, 1856; Möbius, 1857; Kelaart and Humbert, 1859; Garner, 1871, Dubois, 1901, and Giard, 1903, have contributed to our knowledge of the origin of pearls from parasitic nuclei. In 1902, Jameson traced the life history of a *Distomum* from its first host, a duck, to a clam, as its second host, and he succeeded in inoculating the edible mussel, *Mytilus*, by placing it with parasitically infected mollusks, and thus artificially induced the formation of pearls.

"Herdman, in 1903, found in the pearl oysters of Ceylon that a tapeworm larval cyst may become a pearl nucleus, or that in some cases the secretions may be deposited around sand grains, bits of mud, or a fish or some other small animal, in pockets of the mantle epidermis, or again about calco-spherules near the muscle insertions. The surface finally becomes polished, or takes the "orient," and thus reflects the opaline and nacreous tints so highly prized."

CONTRIBUTORS TO VOL. IV

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EDUCATIONAL DEVELOPMENT IN AGRICULTURE

WHAT IS BEING DONE TO EDUCATE THE FARMER THROUGH AGRICULTURAL COLLEGES, EXTENSION COURSES, AND MORE RECENTLY THROUGH THE PUBLIC SCHOOLS

L. S. HAWKINS

During the past quarter of a century agriculture has had an extraordinary development in the United States. Money and efforts have not been spared in the search for better methods and practices or in getting the facts to farmers. Experiment stations, colleges of agriculture, state departments of agriculture and the United States Department of Agriculture have been the important agencies in this work.

Although several states early started experiment stations, the movement became national in 1887 when, through the Experiment Station Act or Hatch Act, Congress made available to each state an annual appropriation of $15,000. In 1906 the second Experiment Station Act or Adams Act, duplicated this appropriation. The early work of the experiment stations was largely policing—analysis and control of fertilizers, feeding-stuffs and seeds, enforcing plant and animal quarantine, etc. Much of this work is still done by them but it is in the field of research that they have made and are making the greatest contribution to the forward march of agriculture. The stations publish the results of their investigations in bulletins available to the farmers. These publications number over seven hundred a year and reach more than a million people. The subjects discussed cover a wide range of science and practice and the information is the basis of present day agriculture.

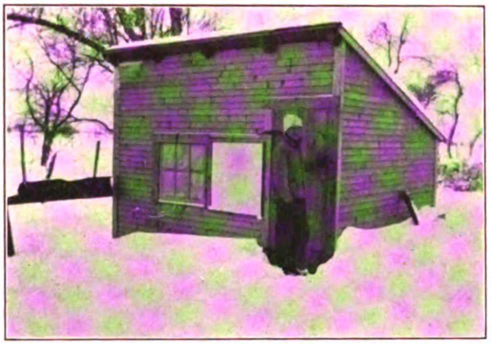
While the stations annually send out hundreds of the staff members to assist at farmers' institutes, local organization meetings, etc., it may be safely said that the great field of the experiment stations is getting together a reliable and available body of knowledge concerning the agriculture of their respective states.

In 1862 Congress, through the first Morrill Act, donated public land to the several states and territories which might provide colleges for the benefit of agriculture and the mechanic arts. Institutions receiving the benefit of this and subsequent acts are now in operation in all the states and territories except Alaska.

"College * instruction in agriculture is given in the colleges and universities receiving the benefits of the acts of Congress of July 2, 1862, August 30, 1890, and March 4, 1907, which are now in operation in all the states and territories except Alaska. The total number of these institutions is 68, of which 65 maintain courses of instruction in agriculture. In 23 states the agricultural colleges are departments of the state universities. In 16 states and territories separate institutions, having courses in agriculture, are maintained for the colored race. All of the agricultural colleges for white persons and several of those for negroes offer four-year courses in agriculture and its related sciences leading to bachelors' degrees, and many provide for graduate study. About 60 of these institutions also provide special, short, or correspondence courses in the different branches of agriculture, including agronomy, horticulture, animal husbandry, poultry raising, cheese making, dairying, sugar making, rural engineering, farm mechanics, and other technical subjects. Officers of the agricultural colleges engage quite largely in conducting farmers' institutes and various other forms of college extension. The agricultural experiment stations, with very few exceptions, are departments of the agricultural colleges. The total number of persons engaged in the work of educa-

* From Year Book of United States Department of Agriculture.

tion and research in the land-grant colleges and the experiment stations in 1913 was 7,651; the number of students (white) in interior courses in the colleges of agriculture and mechanic arts, 47,216; the total number of students in the whole institutions, 88,408 (not including students in correspondence courses and extension schools); the number of students (white) in the four-year college courses in agriculture, 12,462; the total number of



A fourteen-year-old boy and the poultry house built by him in connection with his home project

students in the institutions for negroes, 8,561, of whom 1,795 were enrolled in agricultural courses. With a few exceptions, each of these colleges offers free tuition to residents of the state in which it is located. In the excepted cases scholarships are open to promising and energetic students, and in all opportunities are found for some to earn part of their expenses by their own labor. The expenses are from $125 to $300 for the school year."

These are known as the land-grant colleges. The second Morrill Act in 1890 provided for an annual apportionment of $25,000 to each state for the support of institutions maintained in accordance with the first act, and the Nelson Amendment of 1907 increased the $25,000 to $50,000.

The colleges of agriculture stand for the whole range of country life in both its productive and social phases. In most states the experiment station is located at the land-grant college and takes care of a large part of the investigation work. This leaves the college proper free to devote its energies to the task of organizing the results of research and to teaching. The interior activities in teaching include post-graduate, four-year, two-year, one-year and short courses of instruction for between fifty and sixty thousand students. It is in the field of extension or exterior teaching that the most noteworthy recent development has taken place. Extension work has been described as "comprising all those activities that are not of academic kind and that aim to reach the people and their problems in the places where the problems are. It is conducted mostly away from the institution. It differs from the regular forms of university extension in its purpose to aid the person at home with his special questions, one person at a time." The earlier forms of extension work consisted in sending out bulletins or reading course literature and holding meetings at which representatives of the college and experiment station talked to the people. This work is still being done but everywhere effort is being made to secure local organization. The earlier efforts of extension were paternalistic but the modern efforts are toward fitting the people to progress by showing them how to do things for themselves. Coöperative experiments are being conducted. The college plans the experiment, in some instances furnishes the seed, fertilizer, etc., oversees the starting of the work and analyzes the results. But the farmer does the work and the experiment is worked out on his own farm. Field demonstrations are conducted at which are present all the farmers of the neighborhood who are interested. Traveling schools of from two days to two weeks' duration, in charge of persons specially trained for the work, give systematic instruction in the various branches of agriculture of most interest locally. Farm trains with the best equipment for teaching carry educational impulse and the latest information to thousands. Correspondence and reading courses give individual instruction along all lines of agriculture to many unable to attend any of the schools. The latest movement in

A field laboratory excercise—barrel packing apples

extension work is the location of a resident agent in each county. This agent is variously named: farm bureau agent, county agent, local agricultural representative, etc. His function is to coördinate the various agricultural activities of the county in which he works and to act as the local representative of the college of agriculture and the United States Department of Agriculture in gathering and disseminating information. Thus far these agents have been greatly handicapped by the fact that the farmers look upon them as men who should devise some solution for all their individual problems. Under the operation of the Smith-Lever law which makes liberal provisions for national aid to extension activities, the land-grant colleges will make even greater efforts to carry new ideas direct to the farmer.

State organizations for agriculture are diverse in aim and methods. The usual designations for these organizations are: state departments of agriculture and state boards of agriculture. They have as a general aim the promotion of agricultural interests. In some states they receive large appropriations from the state for performing police duties and carrying on extension activities, while in other states they receive small appropriations and have nominal duties.

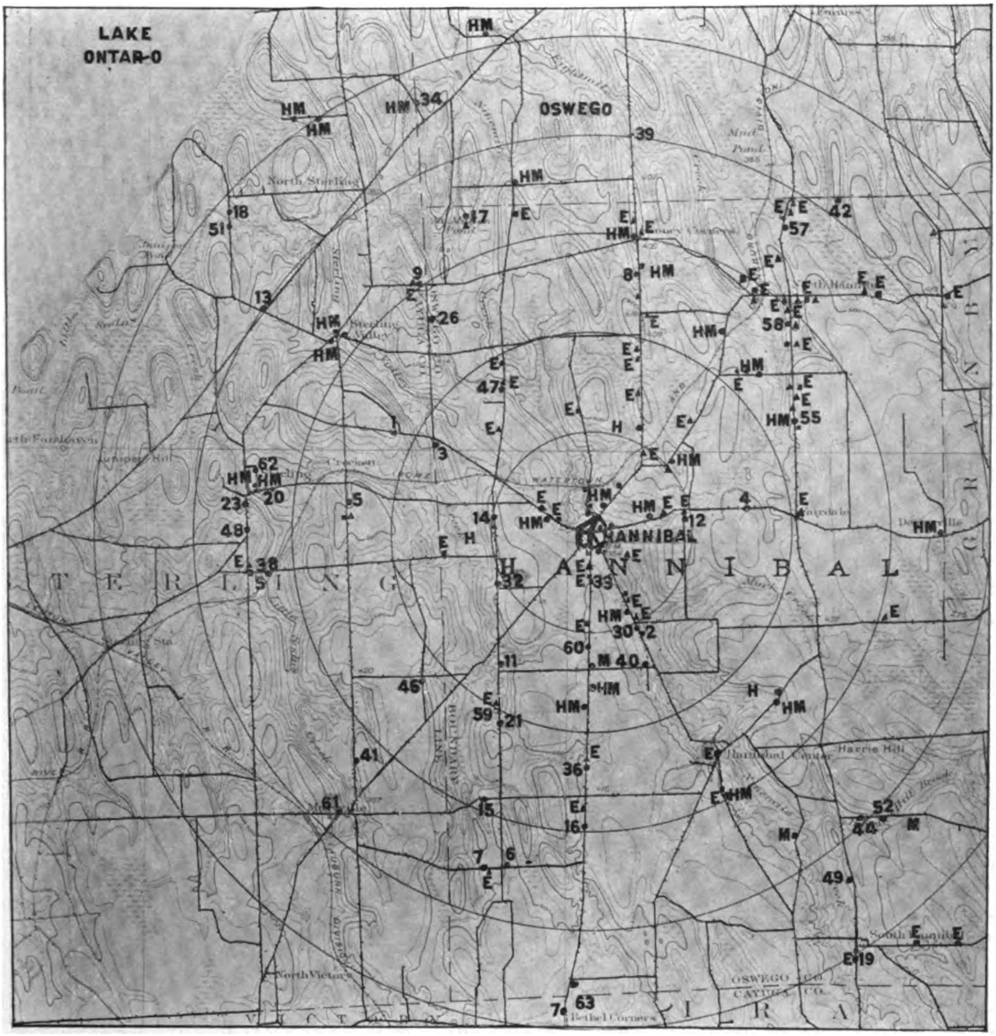
The United States Department of Agriculture was created in 1862. Previous to this time the commissioner of patents looked after national agricultural affairs. In 1898 this department employed 2,500 people and received an appropriation of about $2,500,000 while fifteen years later it had about 15,000 employees and received in round numbers an appropriation of $24,000,000. Of this money approximately $15,000,000 was spent for policing, $8,000,000 for research and investigation and $1,000,000 for extension.

The office of experiment stations in this department supervises the work of all the experiment stations, and to some extent the work of the land-grant colleges. The department publishes technical abstracts of all experiment station literature

Hamburg high school class studying poultry. An eighteen-day laying contest between three white wyandottes, three white leghorns and three white orpingtons was conducted in these pens. The contest resulted in a victory for the orpingtons with a total of thirty-eight eggs

and also many bulletins founded on investigations carried on by its employees on a great range of subjects. These investigations are of a regional rather than a local character and do not duplicate the work of the stations. The extension activities of the department are constantly increasing but are now for the most part carried on through or in coöperation with the land-grant colleges and state departments of agriculture.

With all these efforts to assist the adult who is engaged in the business of farming there has lately grown up a sentiment in favor of offering to the boy who is still in school an opportunity to fit himself for this business should he so desire. As a consequence, various types of secondary schools of agriculture have come into existence. In general these schools may be divided into two classes: (1) separate institutions which maintain only courses in agriculture. They usually own a farm, barns, flocks, herds, etc., and are so costly that relatively few may be maintained in a single state. This means that the students must leave home. The parents lose the work of the boy from "chores" and the boy loses the influence of the home; (2) courses in agriculture in established high schools. These schools serve comparatively small communities and the pupils go home each night. A small community means few pupils and thus there is need for but one or two teachers of agriculture in each school. The cost is low, therefore many of the schools may be established. Since the pupils live at home on farms, no school farms or animals are necessary though small plots are often maintained for demonstration purposes. Neighboring herds, barns, flocks and crops are used for the purpose of laboratory and field instruction. Perhaps the most significant phase of this movement is the fact that each boy who studies agriculture in school works out on the home farm a project along the line of each year's study in school. The teachers are hired for the full year including the summer vacation and when the schools are closed, spend the time in visiting the home projects of the pupils, collecting material for the work of the



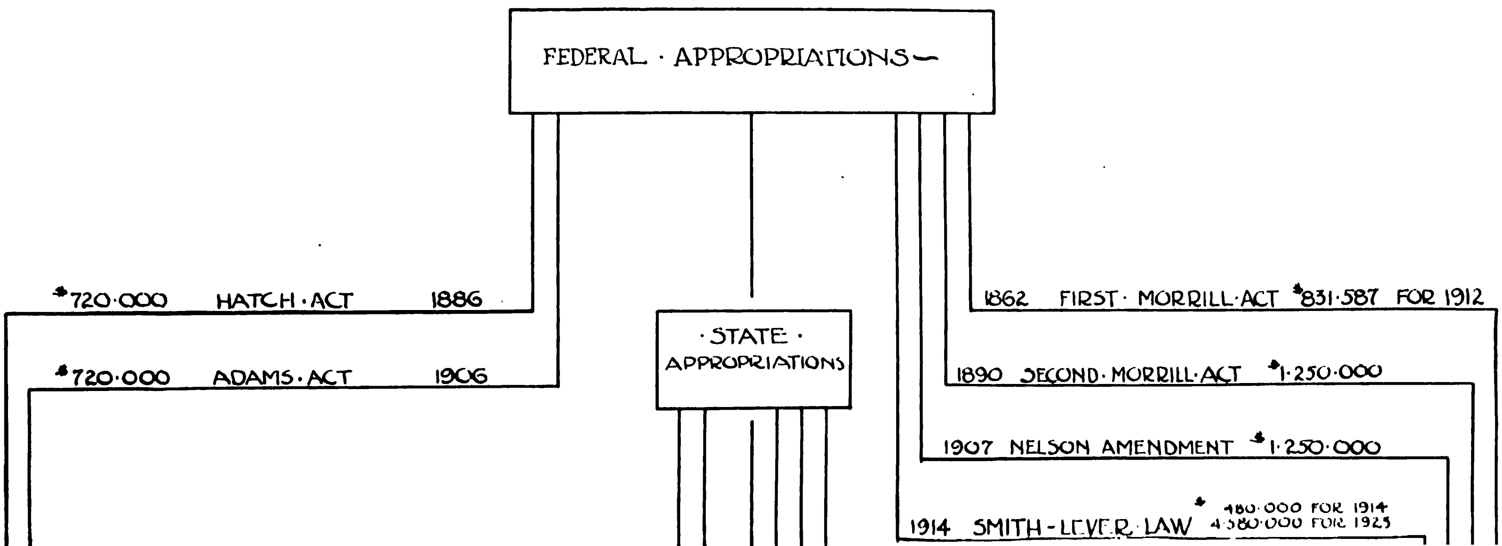
Agriculture and Home-making in the High School at Hannibal, N. Y.

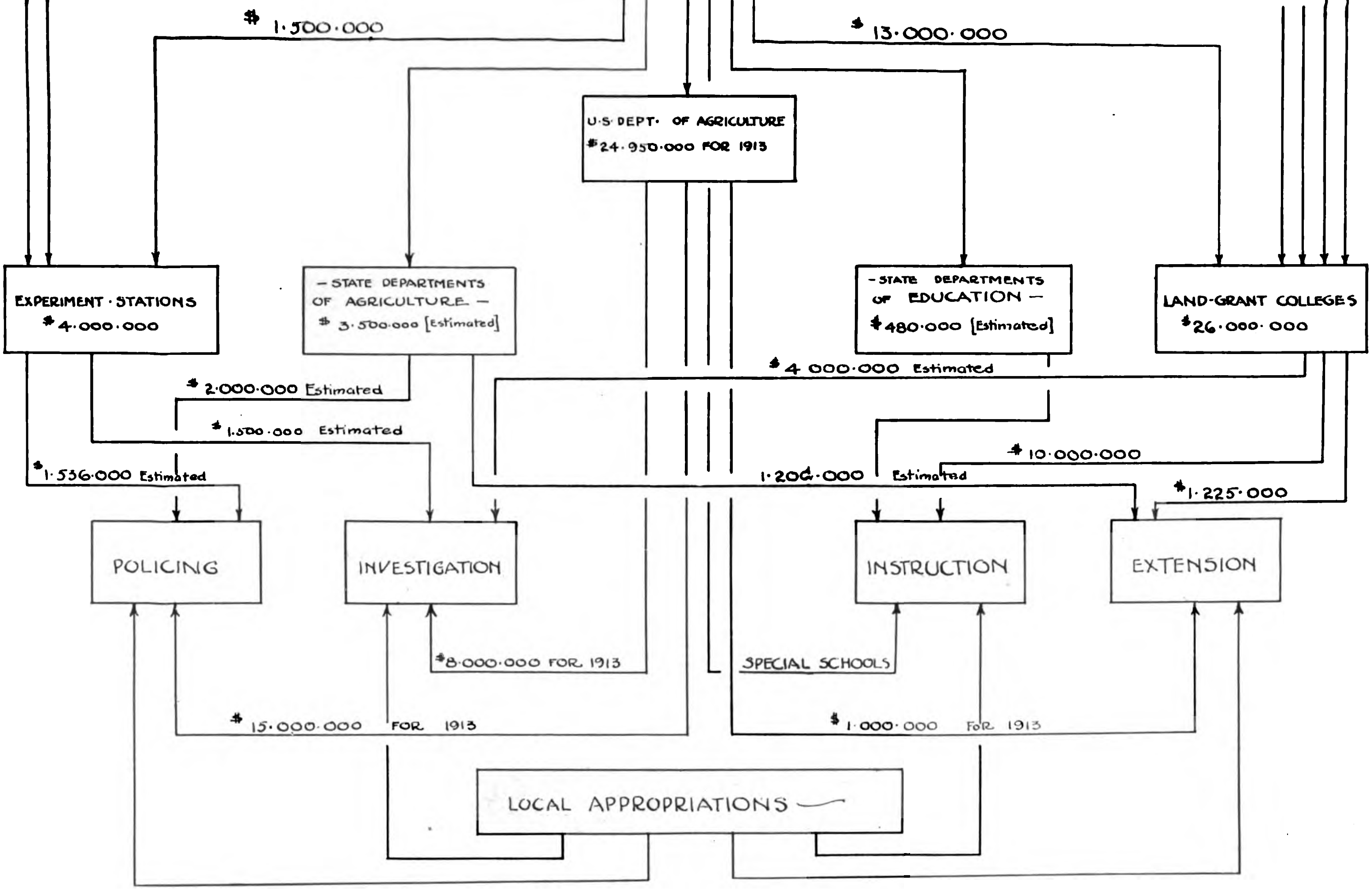
Figures indicate location of homes of pupils in agriculture classes. H. M. indicates location of homes of pupils in home-making classes. E. indicates local coöperation, field demonstrations, use of materials, class visits, etc. The radius of the inner circle is one mile and the outer one five miles.

following year and assisting the farmers of the community when called upon to do so. In these small circles a teacher of agriculture comes into close contact with the people and their business. Experience has shown that the best extension work can be done by persons thus brought into close contact with the people. County agents, colleges of agriculture and the United States Department of Agriculture are working in hearty coöperation with these schools. Many of these schools are conducting evening courses for farmers.

It is to be hoped that Congress, in view of all the money now being expended for adult extension work and college instruction, will see the way clear to adopt the recommendations of the Commission on National Aid to Vocational Education and do something to further the work with boys still in school.

AGRICULTURAL EDUCATION & APPROPRIATIONS IN THE UNITED STATES




$ 1·500·000
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U·S· DEPT· OF AGRICULTURE
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EXPERIMENT · STATIONS
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$ 3·500·000 [Estimated]
- STATE DEPARTMENTS OF EDUCATION —
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LAND-GRANT COLLEGES
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$ 4 000·000 Estimated
$ 2·000·000 Estimated
$ 1·500·000 Estimated
$ 10·000·000
$1·536·000 Estimated
1·200·000 Estimated
$1·225·000
POLICING
INVESTIGATION
INSTRUCTION
EXTENSION
$8·000·000 FOR 1913
SPECIAL SCHOOLS
$ 15·000·000 FOR 1913
$ 1·000·000 FOR 1913
LOCAL APPROPRIATIONS —

WHEN REPTILES RULED THE EARTH*

BEFORE THE ASCENDENCY OF MAMMALS HUGE SAURIANS OF REMARKABLE APPEARANCE, THICKLY SETTLED MANY PORTIONS OF THE WORLD

BY HERVEY W. SHIMER

ONE of the interesting facts that a study of fossils reveals is that through the long course of the geological ages there has been much shifting in the position of dominance among living beings. It is probable that for a long time, in the far-back, early history of the earth, only vegetable life, and that of a lowly seaweed sort, was present in the oceans. Following this plant-life and dependent upon it, evolved the vast panorama of invertebrate life, and for millions of years the seashores swarmed with the mighty hordes of mollusks and starfishes and their kin.

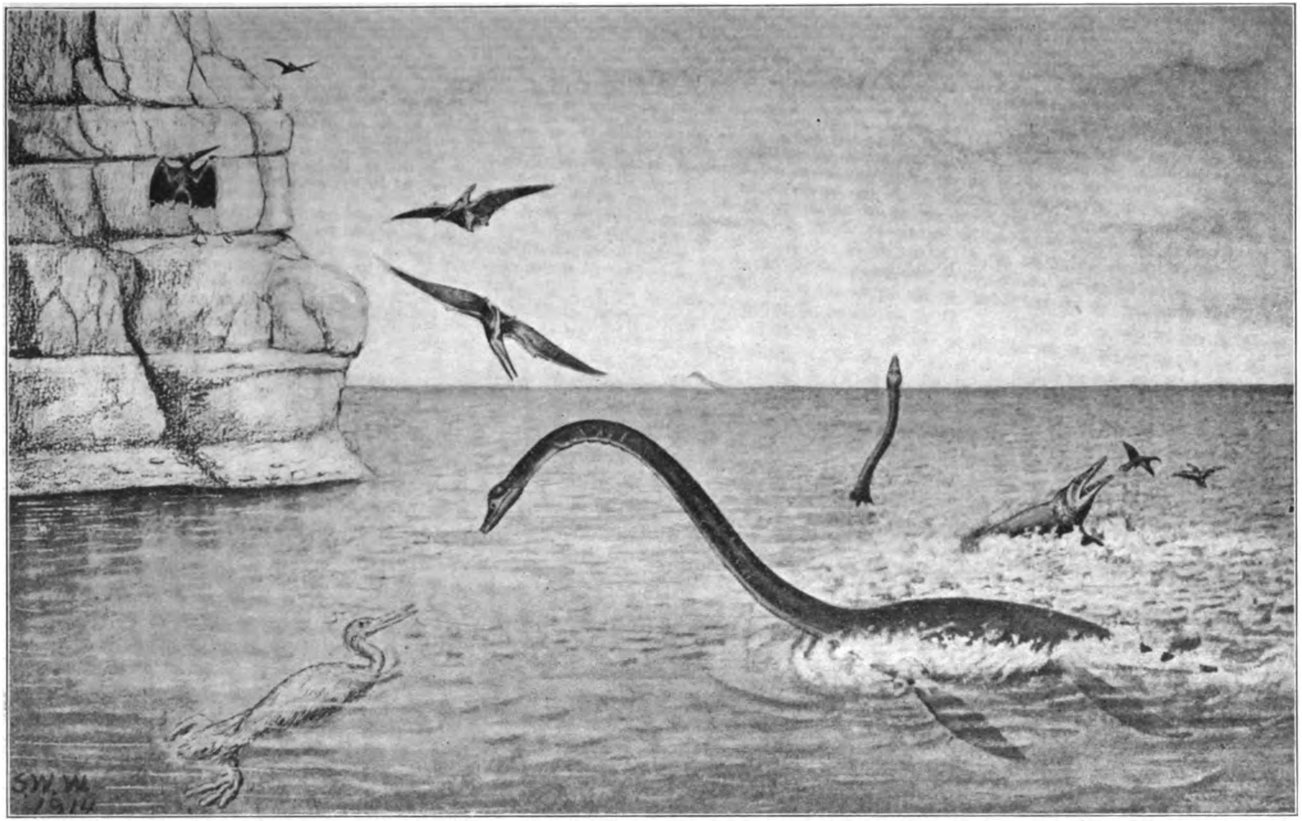
All of the earlier part of the Paleozoic, the second of the four great divisions of the earth's history, is known as the age of invertebrates. Then in the later Paleozoic, backboned animals appeared for the first time and the seas were dominated by the fishes. The amphibians, the group of vertebrates next higher in evolution to the fishes, appeared somewhat later in the Paleozoic, but have never assumed a commanding place in the life of the earth. It was, however, to the present unimportant class of reptiles that the mastership of land and water fell during the Mesozoic, the third of the eras of earth-history. This mastership was held during all of the Mesozoic,—the age of reptiles, and it was only in the succeeding era, the Cenozoic, that mammals assumed their present superiority.

There are at present more than four thousand species of reptiles, falling into four groups,—the snakes and lizards, the crocodiles, the turtles, the Sphenodon or tuatera. Though so different in habits and forms, these possess the common characters embraced in the definition of a reptile as "a cold-blooded, backboned animal which breathes air throughout life." This definition distinguishes reptiles from the warm-blooded mammals and birds on the one hand and from the cold-blooded fishes and amphibians, which are water-breathers during the whole or a part of their existence, on the other.

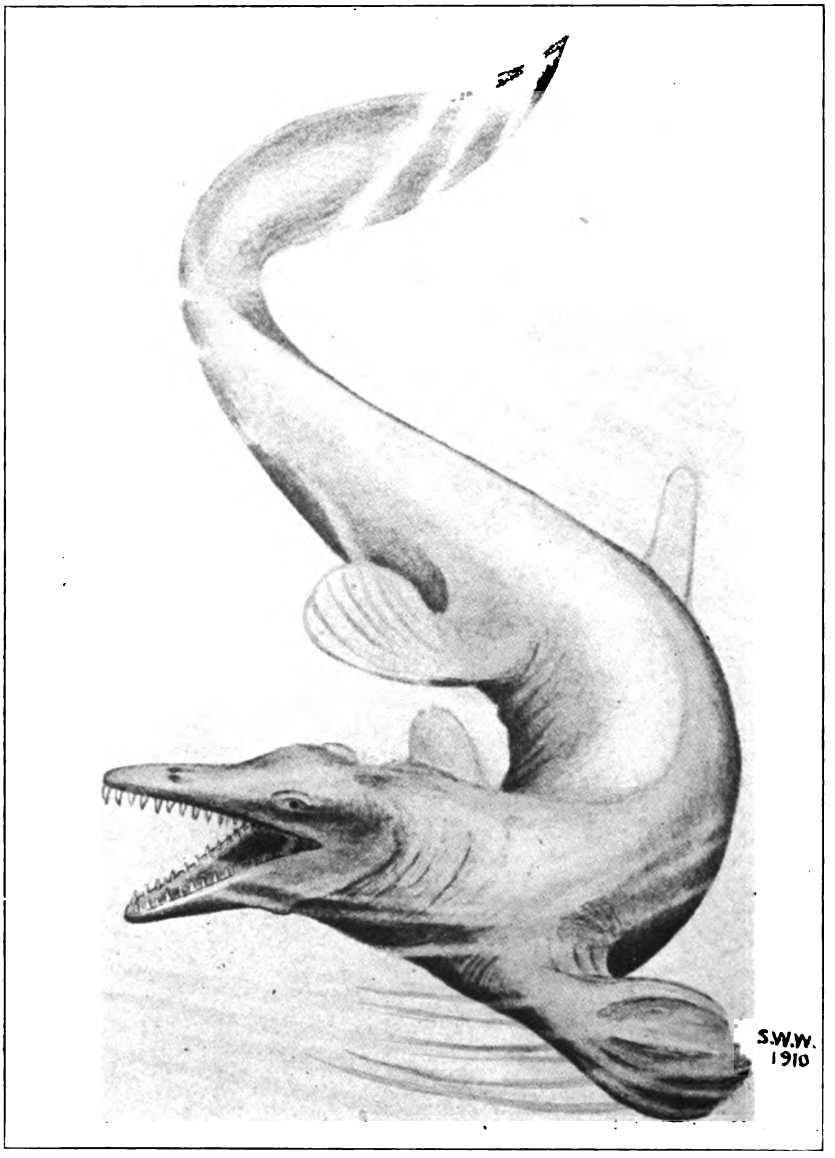
The amount of knowledge which we possess of the appearance and habits of extinct reptiles, slowly built up during long years of patient collecting and study of their fossil remains, is truly amazing. The chief record is naturally their skeletons, usually found in scattered parts, but occasionally preserved as a whole. The flesh is, of course, never petrified, but the form of the living animal may be closely approximated from the study of the bones. Sometimes the scaly skin is preserved in a carbonized condition, while even its color pattern is indicated in the residue of carbon pigment. Fossil stomach contents reveal something of the food habits, while the bony remains of unhatched young and the frequent discovery of bones which have been injured and mended during life, give vivid pictures of their conditions of life.

The earliest reptiles are known from the Coal Measure times of Ohio; by the beginning of the Permian (uppermost Paleozoic) there were many and diverse kinds—water dwellers, marsh dwellers, land dwellers, and even those that could climb trees. Though many genera are known from the Permian of the United States, the most remarkable reptilian fauna of that time lived in South Africa and Russia, some of the African forms

* Largely adapted from "Water Reptiles of the Past and Present," by S. W. Williston, professor of paleontology in the University of Chicago; published by the University of Chicago Press, 1914.



View over the sea that covered Kansas in upper Cretaceous times. In the foreground a plesiosaur, a reptile characterized by the longest neck of any known creature of past or present times, reaching, in the specimen figured, a length of twenty-three feet and possessing seventy-six vetebræ. Likewise in the foreground one of the diving birds of the time, three feet high. In the air and on the rocks are pterosaurs, huge, flying reptiles. The short-necked reptile farther out in the water is an ichthyosaur, in shape and habits much like the dolphin, a swimming mammal of the present seas. Restoration by Williston.



A mosasaur from the chalk deposits of Kansas. These swimming lizards existed by thousands in the Cretaceous sea, not only of that region but of many other parts of North America, of Europe, New Zealand, and South America. They varied in length from ten to forty feet. That they were carnivorous is shown by their large jaws and teeth; they were probably the only water reptiles that would have been dangerous to man had he lived at the time of these ancient seas. Restoration by Williston.

merging into the mammals of the next succeeding period. It was, however, in the Jurassic and Cretaceous periods of the Mesozoic that reptiles attained their greatest prosperity and diversity, dwindling away at the beginning of the Cenozoic to their present unimportant position in the world's fauna, thus closing the Age of Reptiles at the beginning of the Age of Mammals.

Much of the marvelous and diverse development of ancient reptiles took place along the shores and in the waters of the Cretaceous sea of western North America. During the later Mesozoic this sea extended from the Gulf of Mexico on the south to the Arctic Ocean on the north, dividing the continent into two bodies of land. It covered the present site of the Rocky Mountains and extended to the east over quite a part of the present Great Plains. Into it slowly fell sediment, composed of the microscopic shells of animals and plants, and formed masses of almost pure chalk. In these sediments were buried and preserved the remains of the sea life and those of the shore and land, which were brought in by the rivers.

During the succeeding millions of years this interior sea dried up and its bottom was raised far above the present level of the ocean. In these consolidated sediments fossil hunters now find the bones of the ancient animals buried so long ago in the bottom of the Cretaceous sea. The beds of the Niobrara chalk in western Kansas, for example, have furnished thousands of specimens, — mosasaurs, pterosaurs, plesiosaurs, and turtles.

Perhaps the most marvelous of all reptiles are those found in the uppermost Cretaceous beds of America, from Colorado, Wyoming and Montana, and from near Edmonton in Canada. These were the race of dinosaurs, huge beasts, walking on two feet or aquatic forms of enormous size. Many were furnished with extravagant horns and spines.

The flying reptiles of Cretaceous times had bird-like bills and have been sometimes called the kingfishers of the Cretaceous seas.

MELTING POINT OF COPPER ALLOYS

As VERY little information on the melting points of commercial brasses and bronzes can be found in either scientific or technical literature, tests of a few typical alloys were made by H. W. Gillett and A. B. Norton of the United States Bureau of Mines. The results are summarized as follows:

Alloy	Approximate Composition				Melting Point	
	Copper	Zinc	Tin	Lead	°Cent.	°Fahr.
Gun metal	88	2	10		995	1825
Leaded gun metal	85½	2	9½	3	980	1795
Red brass	85	5	5	5	970	1780
Low-grade red brass	82	10	3	5	980	1795
Leaded bronze	80		10	10	945	1735
Bronze with zinc	85	5	10		980	1795
Half-yellow-half-red	75	20	2	3	920	1690
Cast yellow brass	67	31		2	895	1645
Naval brass	61½	37	1½		855	1570
Manganese bronze					870	1600

The melting point given is the "liquidus," or point where the alloy is completely molten. The temperatures are thought to be accurate within plus or minus 10° C. or plus or minus 20° F.

CARING FOR INNER TUBES

THE following instructions as to how best to care for inner tubes comes from a German rubber manufacturer, who furnished the information to the dealers in tubes of his manufacture. His advice as to the best way to preserve the tubes is to blow them up to the pressure of an ordinary rubber ball, hang them on one or two thick, round poles in a darkened room in which a dish of unslacked lime and one of an ammonia solution are placed in the corners on the floor. These precautions keep the air free from destructive acids and retards the process of vulcanization in the tubes.

PLANTS IN HIGH ALTITUDES

INVESTIGATIONS show that there are at least eighty-six species of flowering plants living above the snow line in the Tyrolese Alps. Six of these occur over 1,500 feet above the snow line; one species, the glacial Ranunculus, was met with at a height of over 12,000 feet above sea level.

ULTRA VIOLET LIGHT AND WATER STERILIZATION

THE NATURE AND PROPERTIES OF ULTRA-VIOLET LIGHT AND THE METHODS OF PRODUCING IT—HOW IT IS BEING UTILIZED IN WATER PURIFICATION

BY JOHN F. NORTON

LIGHT consists of electromagnetic waves propagated through the ether. These waves have a transverse motion and a very high frequency. Each kind of light, that is each color, has its characteristic frequency and wave length. For example, in yellow light there may be 508 billions of vibrations per second and the wave length be 589 $\mu\mu$—23.3 millionths of an inch. Light waves giving a violet sensation may vibrate at the rate of 763 billion times per second and have a wave length of 393 $\mu\mu$. Since all kinds of light travel at the same rate the higher the frequency, the shorter must be the wave length. White light is composed of a very great variety of waves and is therefore heterogeneous in character.

If we take homogeneous light,—that is light consisting of waves of only one length,—and pass it from one medium into another of a different density, as from air into a glass prism, the direction of the path of the beam is changed, or as we call it, refracted. This *fact* of refraction has been known for a very long time, being a part of the very small optical knowledge before Newton. In about 1621 Snell formulated the *law* governing refraction. Figure 1 will serve to illustrate. Let *CBK* represent the surface between the two media, and *AB* the beam of incident light. If *EF* is drawn perpendicular to *CBK* and in the plane *ABC*, the angle i will be the "angle of incidence." After passing through *CBK* the beam is refracted along the line *BH*, r being the "angle of refraction."

According to Snell's law $\sin i = \mu \sin r$. This quantity (not to be confused with the sign $\mu\mu$ used before), *i. e.*, the ratio of the sin of the angle of incidence to the sin of the angle of refraction, is called the index of refraction, and is dependent, for any one kind of light, on the media used for the experiment. But lights of different wave lengths are refracted to different degrees,—the shorter the wave length the greater the refraction.

Suppose that white light is passed from the air into a prism. Each wave will be refracted according to its own particular

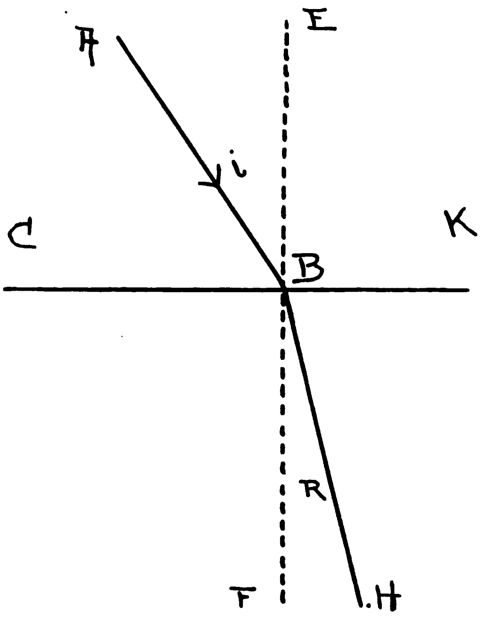


Figure 1

amount,—the waves giving the sensation of red the least and those giving the sensation of violet the most. The white light is thus broken up, or "dispersed," and we have the well-known spectrum.

This spectrum apparently has two fairly sharp ends, but since only certain very definite light waves affect our eyes, these ends are only apparent, and the visible spectrum is but part of the real

spectrum. The light waves toward the red end are the longer, the limit of visibility being about 760 $\mu\mu$. Out beyond this lie the infra-red or heat waves. At the other end of the spectrum the limit of visibility is reached at about 371 $\mu\mu$. But beyond this visible violet light is the most interesting field of all, that containing the chemical, actinic or ultraviolet rays.

This field contains rays having wave lengths from the end of the visible spectrum to about 120 $\mu\mu$, the shortest which have been measured. Ultraviolet light has very great chemical activity. For example, it has very strong action on the silver salts used on photographic plates, and this has led to the use of photography in the study of the invisible violet spectrum. The rays will decompose potassium iodide, which can be easily shown by dipping some filter paper in a starch solution and then in a potassium iodide solution. If the paper is then exposed to ultraviolet light it turns blue immediately, showing that iodine had been iberated. The rays are also active in causing chemical combination,—a mixture of the gases hydrogen and chlorine instantly exploding under their influence,—and certain organic reactions may be made to take place much more quickly than under ordinary circumstances. The light causes fluorescence of uranium glass and of quinine and the luminescence of calcium or barium sulphides. Finally, ultraviolet light has a very distinct and important effect on living matter, and particularly on the lower forms of life, such as the bacteria. More about this later.

One physical property of these rays which it is necessary to mention is that of being readily absorbed by any medium through which they are passing, the shorter rays being more easily absorbed, the actual numerical amount being a function of the medium used. Air absorbs some of the rays, so that the sunlight as it comes to us contains only part of the known field of ultraviolet light. Other gases absorb to greater or smaller amounts.

Sunlight is therefore one source of ultraviolet light. The common carbon arc lamp gives a better supply, but the most satisfactory and practical method is by means of the mercury-vapor, better known as the Cooper-Hewitt lamp. Most of us are familiar with this light, as it is seen in post offices and to some extent in other offices and drawing rooms. The light comes from mercury vapor maintained at incandescence by an electric current. We have stated that the rays are quite easily absorbed. In the ordinary Cooper-Hewitt lamp, most of the very short rays are absorbed by the glass. If the glass is replaced by quartz, a much larger amount of the very active light passes through and is available for use. These mercury-vapor-quartz lamps are therefore the most desirable for practical purposes.

One other method of producing ultraviolet light is at least of some scientific interest. If a glass tube is filled with some such gas as oxygen, nitrogen, carbon monoxide or hydrogen, then most of the gas removed by a vacuum pump, and the end sealed, the tube will contain a small amount of the gas under a greatly reduced pressure. If the tube is fitted with proper terminals and connections, an electric discharge may be passed through the gas causing a luminescence containing the shortest light waves which have ever been studied. These tubes are called Geissler tubes. The region of the spectrum containing these very shortest waves has been called the "Schumann Region," in honor of Victor Schumann who was the pioneer in its investigation.

Schumann was born in Leipzig in 1841, was educated in the schools of that city and of Chemnitz, and was early employed in the design and manufacture of machinery, in which trade he developed great mechanical skill. When about forty years old he became intensely interested in physical science and particularly in photography, finally giving up business in order to devote his entire attention to spectrum analysis and the study of ultraviolet light. The most important instrument used in working with invisible rays is the photographic plate. Schumann developed a very sensitive emul-

sion for these plates and was able to photograph spectra containing rays as short as 120 $\mu\mu$, the shortest ever accurately measured. He obtained the light from Geissler tubes, each fitted with a window made of fluorite, as this was found to absorb less rays than any other available material. After an investigation concerning the absorption of ultraviolet light by gases, and finding that oxygen, one of the constituents of air, had rather high absorptive power for the very short rays, Schumann undertook to overcome this by means of his "vacuum spectrometer," an instrument similar to a spectroscope with a photographic plate in place of the eye piece. The whole thing was made so air tight that the tube could be entirely evacuated, thus removing the objectionable oxygen. Photographs which he obtained of the spectra of gases have never been duplicated in clearness. Schumann died something over a year ago.

We have considered briefly the nature, properties and methods of production of ultraviolet light. There is still one property which has barely been mentioned and is important as it leads to a practical application of the rays. This is its action on living bodies, and particularly on the simplest of organisms known as bacteria. You will recall that bacteria consist of single cells of microscopic size,—approximately 1/25,000 of an inch long; that they occur in three forms,—cocci or spheres, bacilli or rods, and spirilla or spirals; that they reproduce by simple cell division; and that for the most part they are not only harmless but quite necessary for present life. A few, however, are the cause of at least some of man's ailments. Typhoid fever is one of the diseases for which bacteria are responsible. Typhoid is an intestinal trouble and the organisms leave the patient in the discharges. If this material gets on any food or into milk or water and is swallowed by another person, typhoid may result.

In order to prevent the spread of this disease and of other intestinal troubles by means of drinking water, great care has to be taken. If the source of supply cannot be sufficiently controlled to insure safety to those using the water, it is necessary to resort to some artificial means of purification. One method is to pass water through beds of sand about four feet deep. A slimy mass collects on the surface of the sand and strains out the bacteria. This method, known as slow sand filtration, is in use for a large number of public supplies. The filters will deliver from $1\frac{1}{2}$ to 3 million gallons of water per acre each 24 hours. Another method is to add some chemical, such as alum, to the water to produce a flocculent precipitate which acts as a coagulant for the bacteria and other suspended matter. The precipitate is then removed by a layer of sand. This method is called "mechanical" or "rapid" filtration,—the rates of filtration being very high, from 100 to 150 million gallons per acre each 24 hours. Rapid filtration is of advantage particularly in handling highly colored or turbid waters. These filters are also made in sizes sufficiently small for use in manufacturing establishments, institutions, hotels, swimming pools, etc. For still smaller amounts of water there are a number of so-called filters on the market, some of which may work well when kept in proper order, but many of which are useless or worse.

Besides filtration, danger from disease may be removed by adding to the water some substance which will kill the harmful bacteria. Fortunately, typhoid bacilli are less resistant to disinfectants than many of the harmless organisms and so are among the first to be attacked. Now, caution must be exercised in the choice of a substance to be added to a drinking water, as it is obvious that poisonous material or anything giving a taste must be absolutely avoided. The most common chemicals in use for sterilizing water are compounds of chlorine,—sodium or calcium hypochlorites,—the latter going under the name of "chloride of lime" or "bleaching powder." Chlorine gas itself has recently been put into some use, as reasonably good methods of handling it have been developed. These substances are all good disinfectants, are not poisonous in the quantities

which it is necessary to use, and should not leave any disagreeable taste in the water. So far, bleaching powder has proved the cheapest and easiest for general use.

A more recent development has been in the application of ozone. Ozonized air is made to pass through and mix with the water and the ozone coming in contact with bacteria is supposed to kill them. This is not the place for a discussion of the merits of this system.

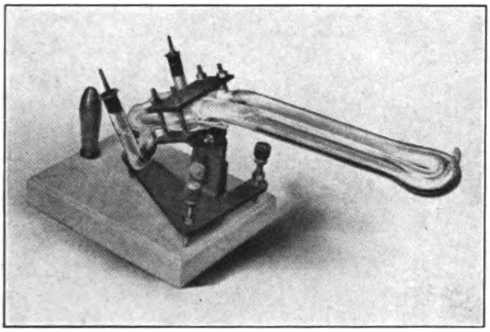


Figure 2

A still more recent method is the use of the ultraviolet rays about which we have been talking. It has been known for a long time that sunlight has an injurious effect on the growth of bacteria, yeasts and moulds. Indeed, this is a matter of common knowledge to the housekeeper. The rays which have the germicidal action are those at the violet end of the spectrum, and ultraviolet light is particularly active,— the shorter the ray the greater its activity. The light practically available is limited by the absorptive power of the material used in making the lamp.

There is certainly no doubt that large numbers of bacteria can be instantly killed if properly exposed to ultraviolet light. The action is probably purely photochemical, and does not take place through the intermediate formation of ozone or other disinfectant. Henri, a Frenchman who has made quite a comprehensive study of the subject, believes that the rays act on the walls of the bacterial cell to produce poisonous products which then diffuse into the protoplasm.

It is only about eight years since the first important work was done on the practical application of ultraviolet light for water sterilization, but some very important improvements have been made since that time. The first problem is the production of the rays. This is done by the use of the quartz-mercury-vapor lamp, and an electric current. Figure 2 represents one of these lamps, the black area being the mercury. In starting, the lamp is tipped so that the mercury makes contact with the two terminals and the current passes. This immediately volatilizes a little mercury. The lamp is then put back into place and the mercury vapor carries the current, giving a strong light, so strong that it is dangerous for the eyes, and can cause a violent sunburn on the skin.

The second problem is to get the rays in contact with the bacteria in the water. Clear colorless water will allow the light to penetrate about one foot, but if either color or suspended matter is present the distance is much reduced. It is therefore necessary to have the water exposed to the light in thin layers, as well as to have it as clear and colorless as is possible. On this account it is often wise to filter a

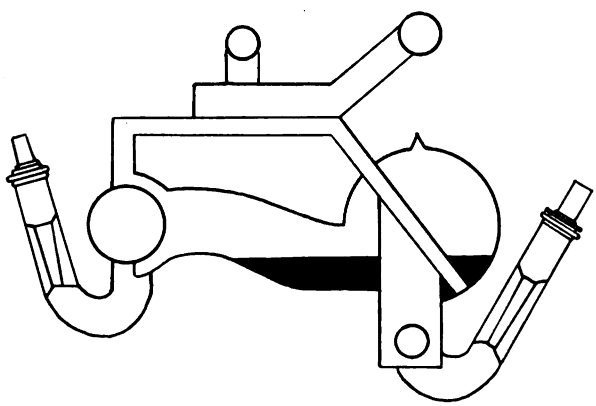


Figure 3

water before treating it with ultraviolet rays. The light would then act as a precautionary measure by sterilizing after the majority of the bacteria had been removed. This will render the water doubly safe.

There are a number of machines on the market for ultraviolet sterilization, the style depending on the amount of water to be treated,—whether it is to be used for a small family, a hotel or factory, a swimming pool, or a public supply. Figure 3 shows a so-called pistol lamp which is used particularly for large supplies.

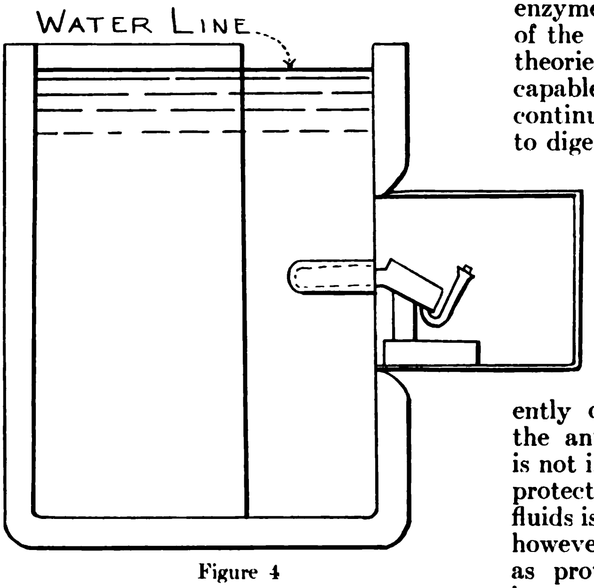


Figure 4

Figure 4 shows how this lamp is placed in a canal with a baffle plate in front of it so that all the water passing through must come in close proximity to the light. If a number of these are placed in succession in a canal, even the most hardy bacteria have small chance of coming through alive.

The only practical drawback to the use of ultraviolet light for water sterilization is that of expense. However, where cheap electricity is available, or where it is obvious that expending a little money will bring a large amount of safety, it is certain that the method ought to find an important field of service.

THE UNSOLVED MYSTERY OF WHY THE STOMACH DOES NOT DIGEST ITSELF

It has often been questioned why the stomach does not digest itself. Proteids in the shape of tissues of other animals rapidily dissolve when introduced into the gastric juice but the stomach tissue itself is never attacked by its own gastric juice. Among the various reasons that have been suggested are the protective influence of the mucous secreted along the digestive canal, and the existence of anti-enzymes, which counteract the activity of the digestive juices. Neither of these theories has, however, been accepted as capable of explaining the complete and continued immunity of the digestive tract to digestion. It cannot even be asserted that it is simply because these tissues are alive that they are thus protected since the living mucous membrane of the urinary bladder, for example, is dissolved by the pancreatic or gastric juice of an animal of the same species. Even the living mucous membrane of the intestine is apparently digested by the gastric juice of the animal to which it belongs if food is not introduced at the same time. The protection of living tissues to digestive fluids is thus limited. On the other hand, however, some aquatic forms of life, such as protozoöns, worms, crustaceans and insects have been kept alive at times for a month, in a solution of trypsin that would quickly have dissolved a mass of dead protein.

So a correspondent to the *Journal of the American Medical Association* for July 18, 1914, concludes that the continued immunity of the mucous membrane of the stomach to an active gastric secretion and of the intestinal mucous membrane to pancreatic juice still remains a mystery. Some unknown protective power of adaptation under certain circumstances must be admitted as one of the innumerable factors of evolution of which we are still ignorant.

H. W. S.

A NEW PUBLIC HEALTH WORK

THE VITAL NECESSITY OF MOUTH SANITATION TO SAFEGUARD AGAINST INDIVIDUAL AND COMMUNITY INFECTION AND RAISE THE GENERAL HEALTH LEVEL

BY WILLIAM R. WOODBURY

One wonders that it has taken so long a time to give to the most necessary and useful part of the human body the recognition due it. For only recently have the mouth and teeth begun to receive proper care and attention. Little thought has been given to safeguarding the gateway to the body—the only entrance through which nourishment comes, and the ready, open and exposed entrance and seat of infection which makes disease.

There is hardly a body ailment which does not find entrance through neglect of this gateway. Even the lungs are made to suffer through the common habit of mouth-breathing—an unnecessary and harmful practice which lets into the breathing organs air not properly warmed and cleaned.

The burden borne by the neglect of the mouth falls heavily, soon or late, upon nearly every member of the community. No family investment saves or earns more in health and capital than the money spent for prompt and thorough care of the mouth and teeth. One thorough mouth cleaning for one boy or girl with several teeth in an offensive and insanitary condition costs more than the preventive care of all the teeth of an entire family for ten years.

So common have decayed and diseased teeth and crippled mouths become that this condition is recognized as The People's Disease. It is rare to find a man, woman, or child who has not become its victim.

We have all been told more than once of the daily care needed to keep the mouth clean; and that it is a means of protection against disease and expense which the individual can control, and for which he alone is responsible. But how many of us take five minutes every morning and every night out of the crowded hours of our daily life to practice this care?

There is a wide discrepancy between knowledge and application; and in this means of conserving health a great public need awaits being met. Good earning capacity demands a sound body and strong health. Poor condition costs money; it blocks growth and development; it whittles away the uncertain health which always goes with poor physical condition; it invites sickness and disease; it spoils usefulness and enjoyment. It is a constant menace to others; and it imposes a burdensome tax upon the community. It adds to the cost of living.

We live in an age of sanitary conscientiousness, and in fact, as well as from the point of common decency, no one has a right to subject his neighbor to the danger of infection, any more than he may do him physical violence.

These facts make the care of the mouth a matter which is of vital concern to community health. Through carelessness and neglect on the part of the individual it has become a part of public health work to spread widely knowledge which will help prevent and control The People's Disease. This growing work keeps before the public constantly the opportunity to learn and to practice the control of one of the most common causes of sickness and economic waste; and to help advance towards solving the complex problem of the prevention of disease.

Closest attention must be given to the prompt care of children's teeth. From the small and seemingly insignificant beginnings of early tooth-rot—conditions which too often escape early discovery and attention—much of the sickness in

childhood comes. In the prevention of sickness it is just as important to control the minor ailments as the major ones. The smaller ones hit us so much oftener. Active and continuous minor attacks of illness finally open up the breach through which general disease enters, and demolishes the body's resistance.

Malnutrition, with its many damaging results, begins with the incomplete chewing of food. The first muscles which the new-born baby uses are the chewing muscles. When the baby nurses these muscles work vigorously; and the increased flow of blood maintained by their use brings to every part of the head and to the brain the full supply of blood needed for their normal and progressive growth and development. Long before the baby can use its arms or legs, or even hold up its head, the chewing muscles are well-developed and doing active work. The constant use of the chewing muscles helps develop a well-formed and symmetrical face and head. These muscles assist in developing and strengthening the teeth; and when the teeth come, and with them the demand for solid foods, the child is ready to manage and use those foods completely.

The chewing and the grinding strength of the jaws and mouth is a nicely adjusted mechanical force. In the full-grown adult a crushing and grinding strength of 250 pounds is demanded to carry on properly the first stage of the process of orderly digestion. Well-fitted artificial teeth—the best that the most skillful mechanician can make—are a poor substitute. Their biting strength is but 25 pounds; and as grinders they are inefficient tools.

The teeth are the hardest organs in the human body, and the most durable when given reasonable care. In their structure and material they are harder than the bone substance and structure. Every one of the permanent teeth is built to last through all the years of life. There is not one tooth too many; and the work of them all is demanded all the time.

Never should a child be sent to school whose mouth and teeth cause poor condition or disgust. Such a defective child becomes a public charge which increases the tax upon the community purse to carry it through its school years, to develop not infrequently into a defective and inefficient man or woman. Most of the problems of school hygiene are those imposed upon the community by the poor physical condition which the child brings when it begins its school work.

Another burden which taxes the community is that children with neglected and crippled mouths are ready victims of the infectious diseases—diphtheria, scarlet fever, and measles. They invite these diseases; and their foul, neglected mouths are breeding places and carriers of the active agents of infection. They are a constant menace to the health of all their schoolmates, and wherever they go. Children play very close together, and they have a habit of putting everything in the mouth.

Mouth conditions are of the greatest practical importance in tuberculosis. In the prevention and control of tuberculosis the largest and surest benefits come from good sanitary conditions; and mouth sanitation is of vital significance. A neglected mouth and decayed hollow teeth are important factors in spreading this disease.

Nearly every kind of bacteria at some time finds entrance and takes refuge in the human mouth. Pneumococci, the infection which causes pneumonia, can be found quite generally in the mouth. Though always a menace, but not dangerously aggressive until, through a greatly reduced vitality and depleted physical condition, an ineffective resistance is reached, the danger is ever present in a neglected mouth.

In his account of a visit to the American Ambulance Corps in Paris, Peter McQueen describes two or three remarkable things which he saw and heard: "In the first place, the Americans begin their work of healing by having the free services of the best American dentists in France two whole days a week. Every patient has his teeth looked after. They found that the English have the worst teeth and the Arabs have the best. They found many men suffered more from their

teeth than from their wounds. Inflamed gums were very common among the French and English. The Moroccans and Algerians have almost perfect teeth. By attending to the teeth, the American doctors cure the wounded ten days faster than any other corps now working either with the Germans or the Allies."

Of all our diseases cancer, to-day, has the largest mortality from among those who have reached adulthood. Of those who have attained the age of forty, one in eleven dies, and death comes at the time when the individual is in the height of usefulness and activity in the home and community. Death from cancer seems to be increasing. The chief facts known about this disease are that it begins as a definitely localized disease in some point of irritation, and, if neglected, spreads to other parts of the body. Irritation due to a diseased, sharp tooth, and persistent indigestion provoke cancer. A crippled mouth and diseased teeth, and careless incomplete chewing are highly important factors in maintaining persistent indigestion.

Here, again, public education in the prompt care of the mouth and teeth needs to be urged. It is an undeniable factor in helping prevent the worst remaining disease.

Ninety-five out of every one hundred adults have receding gums—Rigg's Disease; and too often the unhealthy condition is permitted to develop into active sources of infection which poison the whole body. The abscesses which may develop about the teeth-sockets in the gums lead to the loosening and loss of the teeth one by one. When this condition has fully developed, attempts to save the teeth are ineffectual—it is too late.

The absorption of infection from around diseased teeth mav so damage the heart as to cause leaky valves. Rheumatism can develop from the oftentimes unsuspected abscesses concealed in the mouth.

Man has twenty teeth with which to grind his food. If he does not do the necessary grinding throughout his entire life, and swallows his food in chunks, washing it down into his stomach with liquids, he invites sickness, disease, and premature death.

A whole clean mouth helps make a healthy body; it helps make and keep useful health; it prevents infection and disease from disorganizing the functions and work of every organ in the human body; and it prolongs life. A neglected mouth and poor nutrition makes defective, inefficient, and diseased children, women, and men.

From every quarter, near and remote, comes a plain call for active public health work everywhere for prompt and constant care of the mouth. Individual and community efficiency and economy demand checking the present and generally wasteful expenditure of health and human life; and of eliminating, so far as is possible, every factor which works for crippled health, quickly spent lives, and needless sacrifices and suffering. Such work is well worth while.

With this work wisely planned and with its foundations well laid there needs to be fullest scope and broad and natural ways for increasing its certain benefits. Facts seen on every hand—and in so many mouths—facts which so many of us know from our own personal experiences, point the necessity for this work. The lessons told by neglect of the gateway of the human body stand out clearer to-day than even only a few years back. More and more they are beginning to take firmer hold upon us. To attempt to get through life without taking just account of these facts and lessons hastens physical disaster and untimely dislocation of the affairs of life. Both the fixed and quick capital which every man and every woman needs are consumed much too quickly and wasted. It is good business—it is practical, wise economy to reduce to the minimum the outlay in money and time for repairs and upkeep of every part of the body.

Nutrition—the first factor in maintaining life—comes from the food which enters the body. The fullest benefit and a large part of the enjoyment from our food comes from chewing. When the work of the mouth can not be done properly an added and overburdening

Five numbers of SCIENCE CONSPECTUS are published during the year.

weight of work is piled upon all the other organs—work which none of them can do. When the gateway is kept whole and clean, and every part of the mouth and all the teeth do their full work, nutrition begins right; a damaging tax does not fall anywhere.

Safeguarding the mouth and giving this body gateway early, prompt, and constant preventive protection is worthy of our best efforts; the work is far-reaching. Broadly speaking, and by the letter, too, every undertaking which works towards the benefit and upbuilding of the human body of this generation and of the next and following generations of men and women holds an important place in public health work.

Nowhere is there an institution which is doing more and better work, and out of which more thorough and more far-reaching good can grow in so many directions, than is being done by the new Forsythe Dental Infirmary for Children, of Boston. The first institution of its particular kind for promoting public health, it stands out as the pioneer in a new field of health work—a field in which much patient work is waiting to be done.

Dedicated and devoted wholly to children under sixteen years of age, it offers to thousands of the rising generation of men and women opportunities which their parents cannot buy for them. It gives them the opportunity they need for the timely repair of defects and beginning damage. This noble institution, and those of its kind which are to come, enables *children* to establish and maintain the upkeep of sound body health; helps them learn to practice that care which diminishes sickness; saves their health, time, and money; adds to their capacity for living; and prolongs useful lives.

SOFTENING RUST

A RECENT issue of the *Brass World* contained a simple method for removing rust. It consists in dipping the articles first into a strong hot potash bath for about half an hour, and then immersing in a cold muriatic acid pickling solution, composed of two parts of water to one of acid. This removed the rust in a few minutes, leaving the metal apparently attacked but very little. The previous soaking in the strong hot potash solution is responsible for this rapid pickling, as a test proved, for without the previous dipping, sixty-five minutes was required by the acid bath, against four minutes when previously treated in the potash bath. Apparently a chemical reaction is set up, changing the character of the rust, softening it and making it readily soluble. The pieces that have been treated in the potash bath have a smooth and glossy finish.

Science Conspectus

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VOL. V 1915 No. 3

The Aim of Science Conspectus

Not many years ago a man might say, " I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

VOL. V 1915 No. 3

PRESENT STATUS OF SUBMARINE BOATS

A DISCUSSION OF THE PRINCIPAL FEATURES OF UNDER-WATER WAR CRAFT, THEIR ARMAMENT, MANEUVERING, LIMITATIONS AND MILITARY VALUE

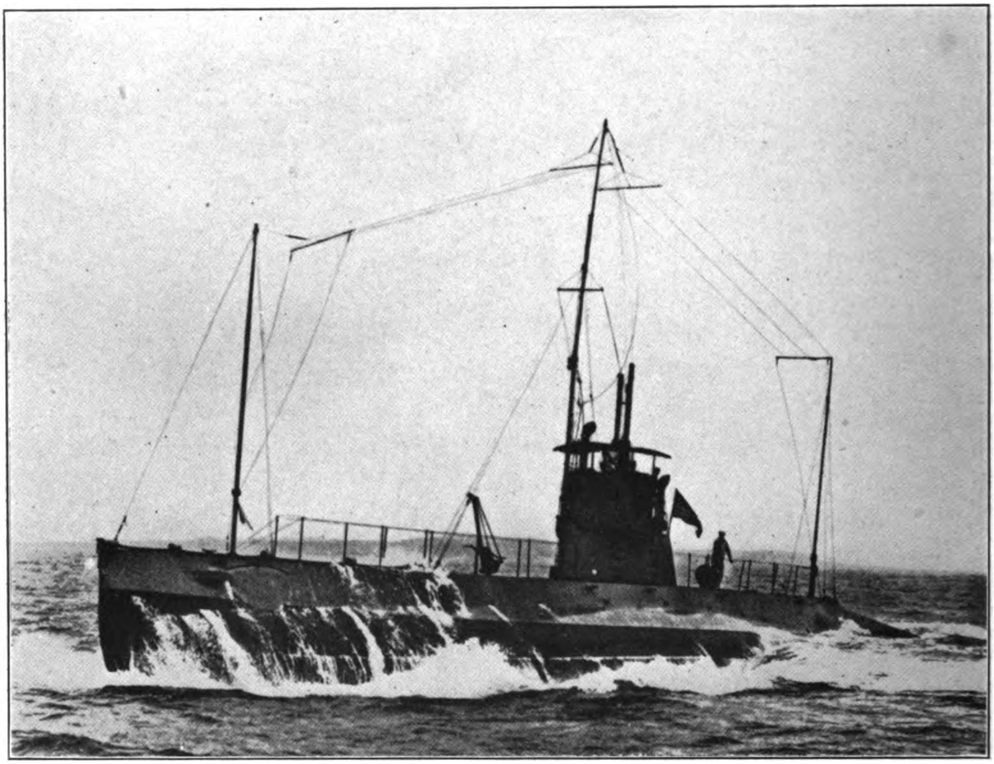
BY WILLIAM HOVGAARD

SUBMARINE boats occur in two varieties, "Submersibles" and "Submarines." Although the line between the two types is not always easy to draw, each of them in its pure form possesses certain characteristic features which it is of importance to understand.

SUBMERSIBLES AND SUBMARINES

A "submersible" may be defined as a submarine boat in which predominant importance is given to the requirements of service in the surface condition, while a "submarine" is designed more particularly with regard to the submerged condition. Hence the submersible is given a ship-shaped external form, while the submarine is more nearly cigar- or spindle-shaped with circular sections. The ship-shaped form of the submersible is, however, attained without abandoning the advantage of the circular section which is maintained throughout an inner spindle-shaped "strength-hull," being the form best adapted to resist the pressures of the water. Between the inner and the outer shell are water-ballast tanks and oil tanks, whence the strength-hull may be of small diameter well suited to resist great pressures without going to excessive scantlings. The outer hull, not being exposed to great pressures, may be lightly built, but will yet in some measure protect the inner hull against damage by collision. The ballast and oil tanks may, with a relatively small addition in hull weight, be made very large, whence a great reserve buoyancy and great radius of action can be secured. In a submarine the tanks are chiefly inside the strength-hull and cannot, therefore, be very large without unduly increasing the diameter of the hull and hence its tendency to collapse.

Speaking broadly the submersible has better seagoing qualities, and higher speed on the surface than the submarine, but the form is not so favorable for driving under water. Most early boats were submarines. It was natural that inventors, especially those not acquainted with the requirements of naval service, should direct their efforts especially to navigation under water and that they should underestimate the importance of qualities required for work on the surface. At present the general trend of the development is toward the submersible type. Of recent years, therefore, the submarine, where it is still retained, has been made to approach the submersible more and more by enlarging the superstructure and giving it a more ship-shaped form. In English subma-

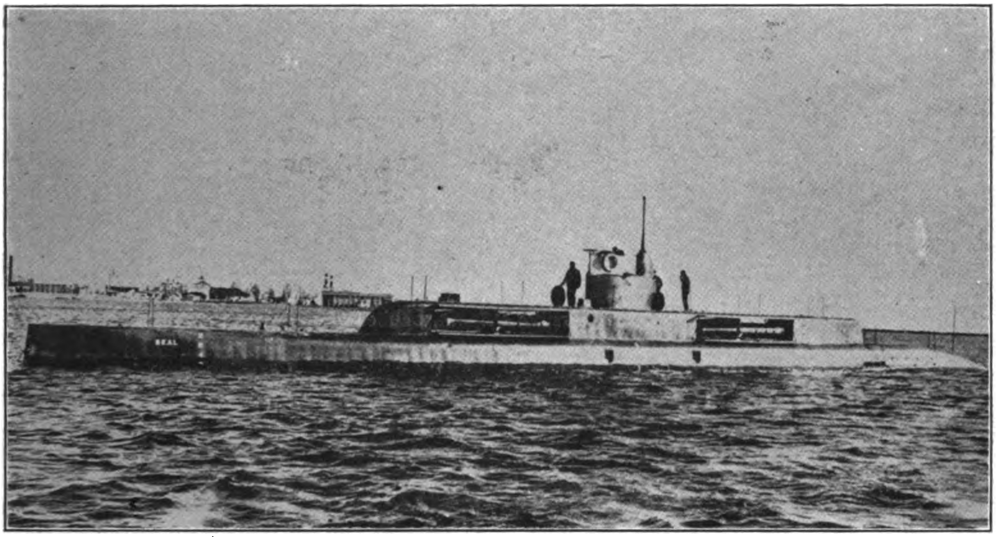


U. S. Submarine *K1*, Holland type (Electric Boat Company)

rines side structures have been added. The reserve buoyancy in the early submarines was only about 5 per cent. of the light displacement but has been gradually increased to about 18 or 20 per cent. In submersibles, on the other hand, the reserve buoyancy has been reduced from about 72 per cent. in the first boat of this type, the French *Narval*, to about 35 per cent. or less in recent boats.

The submersible, as, for instance, the *Germania* type, has a relatively high center of gravity and hence small stiffness in submerged condition on account of the high position of the tank structures, while in the surface condition the stiffness is in some cases excessively great due to the large area of the waterline. The submarine, exemplified by the *Holland* boats, has a low center of gravity on account of the low-lying water tanks and therefore great stiffness in the submerged condition but small or moderate stiffness on the surface. The *Laurenti* type, where the ballast tanks are partly below the strength-hull, partly above or, at least, very high, are intermediate between the *Germania* and the *Holland* type in this respect.

In order to obtain sufficient stability in the submerged condition submersibles must generally carry a considerable amount of keel-ballast. This of course is a drawback, but also most submarines carry some ballast. Part of the ballast is generally detachable, often referred to as a "safety keel," to be let go in case of emergency. In passing from the light to the submerged condition and *vice versa* a point will exist where the stability is a minimun, being reduced by the presence of free water in the tanks. The designer must, therefore, carefully determine the conditions of stability in all intermediate positions in order to satisfy



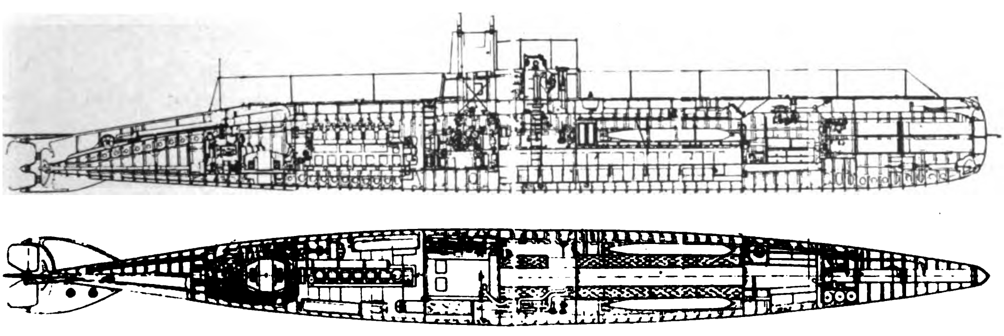
U. S. Submersible *Seal*, Lake type

himself that a proper metacentric height is always maintained. If the stability vanishes at any point the boat may heel over to a considerable angle before equilibrium is restored or may even capsize.

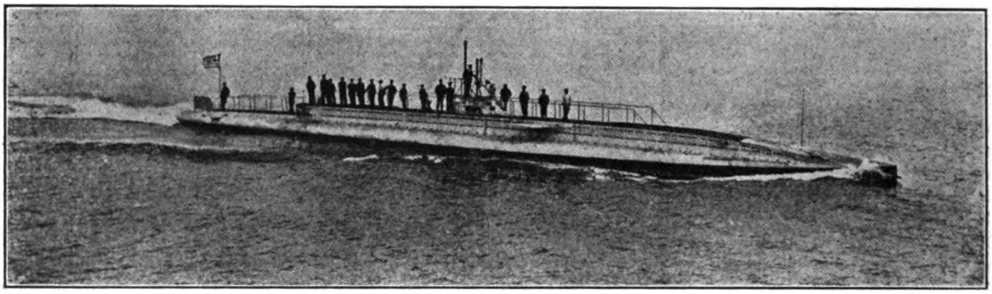
STRENGTH AND CONSTRUCTION OF HULL

The hull of a submerged vessel is exposed to an external water pressure which is directly proportional to the depth of immersion. Already at a depth of 200 feet the pressure is about 100 pounds per square inch, and since the depth of water in the ocean is generally more than 10,000 feet, boats cannot be constructed to withstand the pressures at all depths which they may encounter. It is therefore necessary to assign a limit to the head which a boat is required to resist. Generally there will be no object in going deeper than required to clear the bottom of vessels on the surface, that is, to a depth of about 75 feet, but accidentally boats may descend involuntarily to greater depths. Usually the head to which boats are tested is about 150 feet, in the United States Navy it is 200 feet. A certain margin of safety is, of course, applied in the construction, but if a boat goes much beyond its test depth it is liable to collapse. In most boats the strength-hull is made of circular section as stated above.

The Whitehead boats and other boats



Danish Submarine *Havmanden*, Holland type (Whitehead)

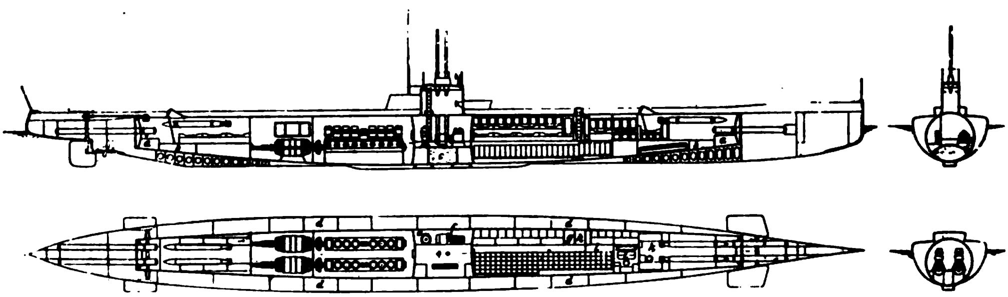


Greek Submersible *Delphin,* Laubeuf type

of the *Holland* type have internal frames. As seen from the midship section of the Danish submarine *Havmanden*, the Whitehead boats in some cases have oval sections even amidships, because this form is convenient for operating in shallow water. Some boats, such as those of the *Germania* type have no frames. Boats of the *Laurenti* type appear to use the frame-work between the inner and outer hull as a means of stiffening the strength hull.

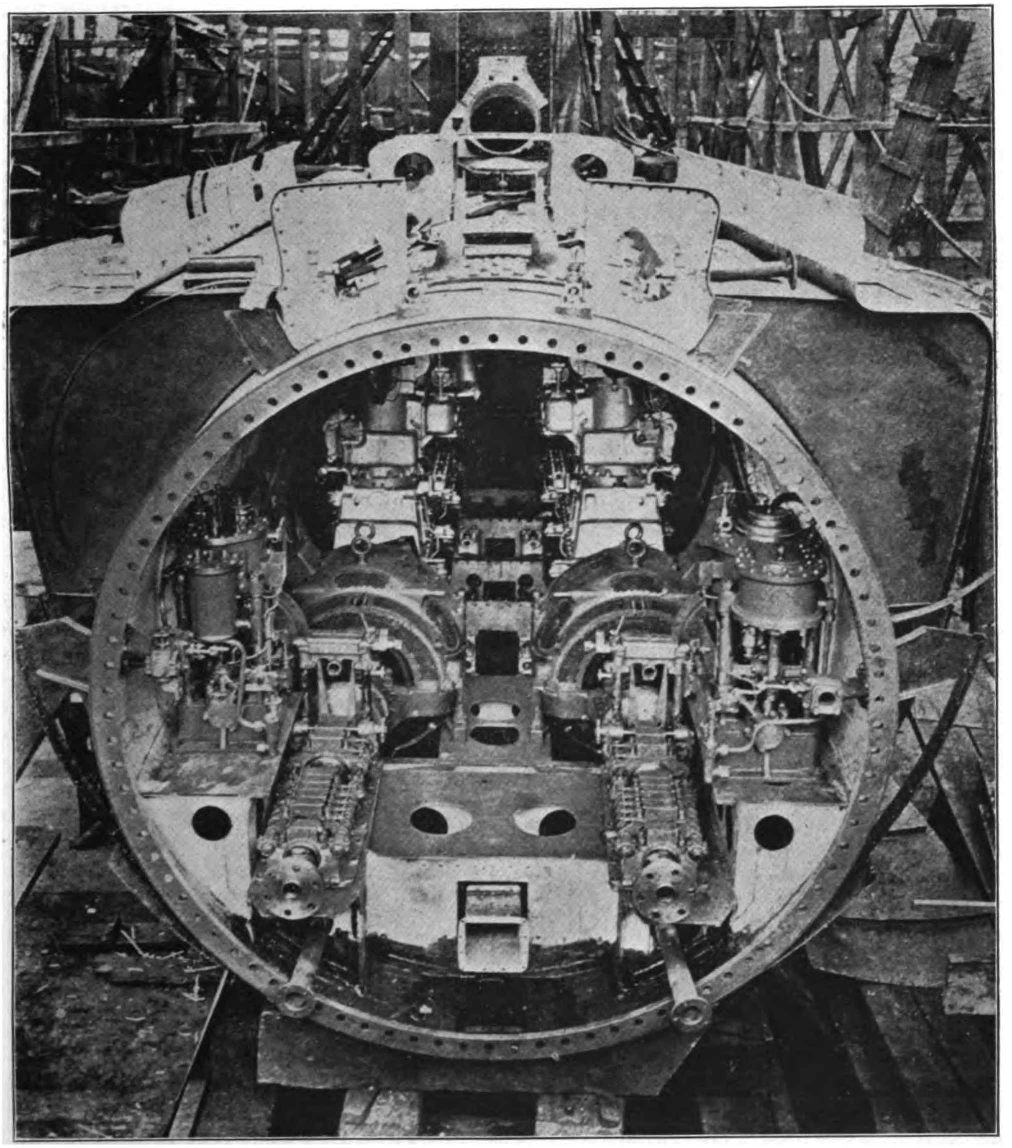
STEERING AND NAVIGATION

Steering in a horizontal direction takes place as in ordinary vessels, but steering in the vertical plane has caused many difficulties to early inventors. As late as 1901 a German authority, Professor Busley, deprecated the value of submarine boats on that ground. Mr. Holland introduced diving and emerging by inclining the boat at considerable angles, while most other inventors preferred to keep the boat as nearly as possible on an even keel and to effect great changes in depth either by pumping water in or out of the boat, or by means of horizontal propellers, or by so-called "hydroplanes." The last method appears to be that which is mostly used in submersibles. Hydroplanes are similar to rudders, sometimes fitted amidships abreast of the center of gravity of the boat, sometimes placed forward and turned the same way as the aft rudders. In all cases the object is to produce an upwards or downwards force driving the boat up or down parallel with itself. This method is generally considered safer than the "porpoising" used in the *Holland* boats. Once the desired depth is attained, it is preserved by means of the horizontal rudder in the same way as when steering a course on the surface, but with this difference that even small deviations from the given course line (depth) are not here permissible. For guidance in steering a depth gauge and a clinometer are used. Steering in the vertical plane requires considerable skill and experience.



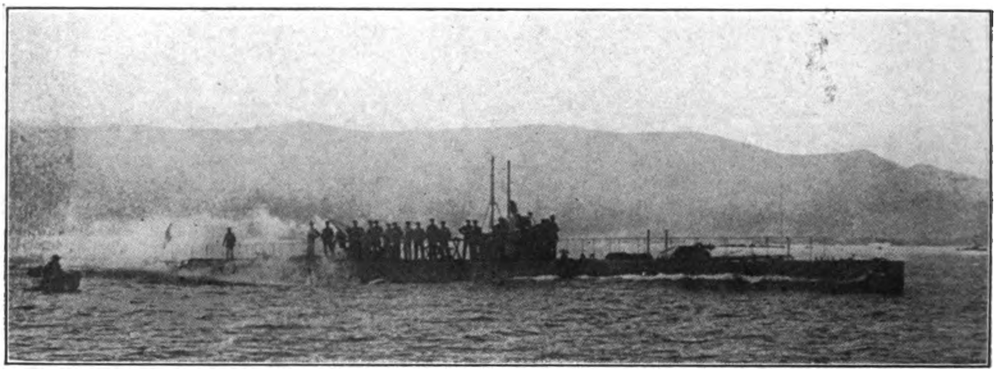
a Trimming Tank
b Torpedo Tank
c Water Ballast
d Oil
e Main Ballast Pump
f Air Compressor
g Cupboard
h Water Closet
i Commanding Officer
k Officers
l Petty Officers

Submersible of Germania type



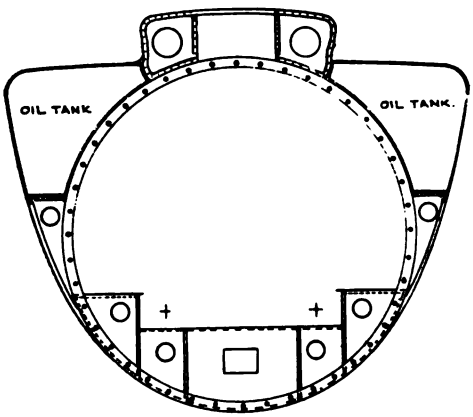
Internal View of Submersible *Kobben*, Germania type

In order to navigate, the submarine boat must be provided with a reliable compass and, even when submerged, a view of the horizon must be obtainable at any time. An ordinary magnetic compass is not quite reliable even when placed in a conning-tower of bronze, but recently the advent of the gyro-compass has provided a means of accurately determining the direction independent of magnetism. The faculty of vision when the boat is submerged, as it must be when making an attack, constitutes one of the most important and difficult problems connected with submarine boats. The water is practically opaque and it was therefore necessary in early boats, when going under water, to emerge



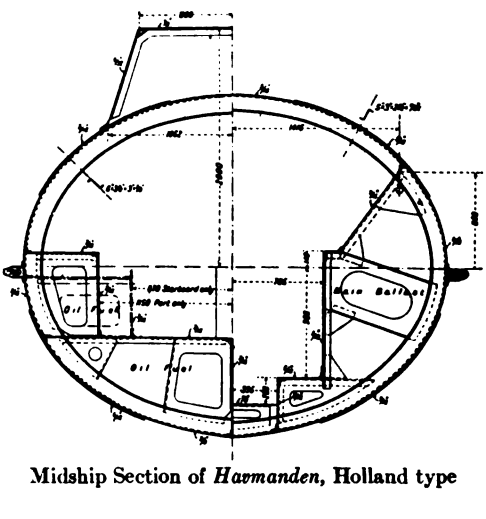
Italian Submersible *Foca,* Laurenti type

from time to time so as to obtain a view from the conning-tower, but evidently this mode of navigation was anything



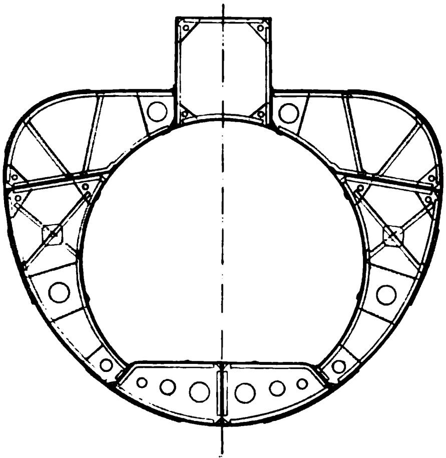
Midship Section, Germania type

but safe since the presence of the boat was thus revealed to the enemy. Already in the eighties and nineties optical tubes were introduced of simple construction, invented by Marié Davy in 1854 and gradually perfected. In its simplest form the optical tube had a mirror at each end inclined at 45° to the axis. The tube, being fitted watertight in the top of the boat, projected a few feet above water when the boat was immersed and thus a view of the horizon might be obtained, but the arc of vision was at first only one or two degrees, and the image was very imperfect. The mirrors were replaced by prisms, lenses were introduced, and during the nineties several improvements were made, but not till about ten years ago was any serious progress made. Then, in a few years the optical tube or "periscope," as it is now usually called, was developed to a high degree of perfection, enabling the submarine boat to perform attacks without showing anything but the top of the periscope occasionally above water, at the same time obtaining a perfect view of the enemy. The improvements comprise a larger field of vision spanning an arc of more than 50°, as large or greater than that of the human eye, convenience of observation, and the addition of means for measuring distances and indicating directions. The magnification of the



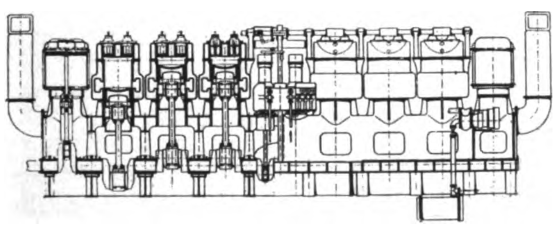
Midship Section of *Havmanden,* Holland type

object is only about 1.5, which is found to give to the observer the same impression as when using the naked eye. By using the utmost refinements of optical art and science a perfect image of un-



Midship Section, Laurenti type

surpassed clearness and distinction is obtained. Mechanical power is employed for handling the tube, enabling it to be pushed up and down readily and quickly and to be turned round its axis. The length of modern tubes is up to 25 feet with a diameter of about 6 inches. The head of the tube projects from 10 to 20 feet above the hull. Difficulties still exist due to the vibration of the periscopes and spray on the front glass, but they are of secondary importance. Instruments have been constructed by which an all-round view of the horizon can be obtained without turning the tube, but have not proved quite satisfactory. The perfection of the periscope was the last link in the chain of inventions and improvements that were needed to endow the submarine boat with positive military value.

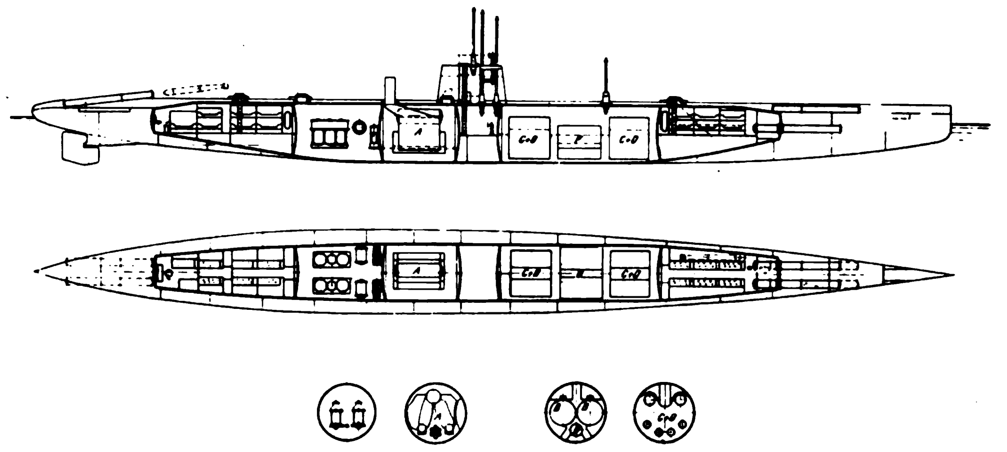


Diesel Engine, Germania type, 900 H. P., 450 rev. per min.

VARIATIONS IN BUOYANCY

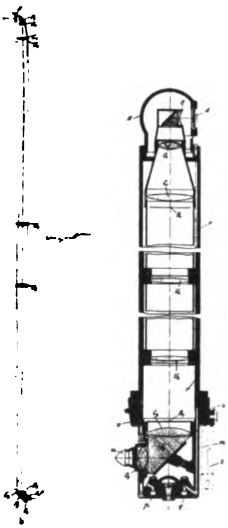
In order to go from the light to the submerged condition and *vice versa* it is necessary to admit or to discharge water. Main tanks of great capacity must therefore be fitted, provided with large sea-valves and powerful pumps. The water may if desired be forced out of the tanks by compressed air. The time occupied in passing from the surface to the submerged condition should not be more than about from four to five minutes. This, of course, is a point of great military importance. When a boat is completely submerged the main tanks are always entirely filled, and its weight is generally so adjusted that it falls a little below the buoyancy, leaving a tendency for the boat to rise to the surface. This tendency is overcome dynamically when the boat is in motion either by a slight inclination of the axis or by hydroplanes. The fine adjustment of the buoyancy takes place by means of a central auxiliary tank of moderate capacity used to compensate for incidental disturbing causes, such as variation in the specific gravity of the sea-water or consumption of stores. Smaller tanks near the ends of the boat permit an adjustment of the trim. Special tanks are fitted for compensating for such definite changes in weight as when a torpedo is fired and another inserted in the tube. In some boats a so-called "floating-tank" is fitted, which serves to compensate automatically for incidental variations in buoyancy occurring while the boat is under way; it is connected with a continuously acting pump which is worked in conjunction with the horizontal rudders. A considerable amount of buoyancy can be obtained almost instantaneously by the release of a safety-keel consisting of detachable blocks of lead ballast which are let go in case of emergency.

The superstructure which is above water in the light condition is self-bailing. In some boats it is built entirely and permanently open, serving



Boat with Soda-Boiler, d'Equevilley type

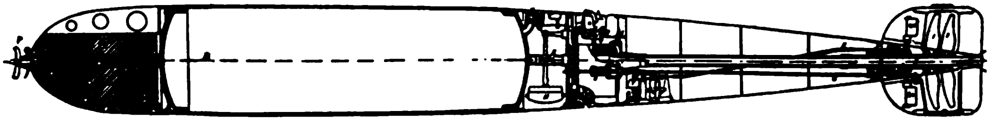
only to provide a raised platform, but in most boats it is a watertight structure provided with large and numerous valves that can be readily closed when the boat is in light condition whereupon the superstructure will add to the reserve buoyancy and the stability.



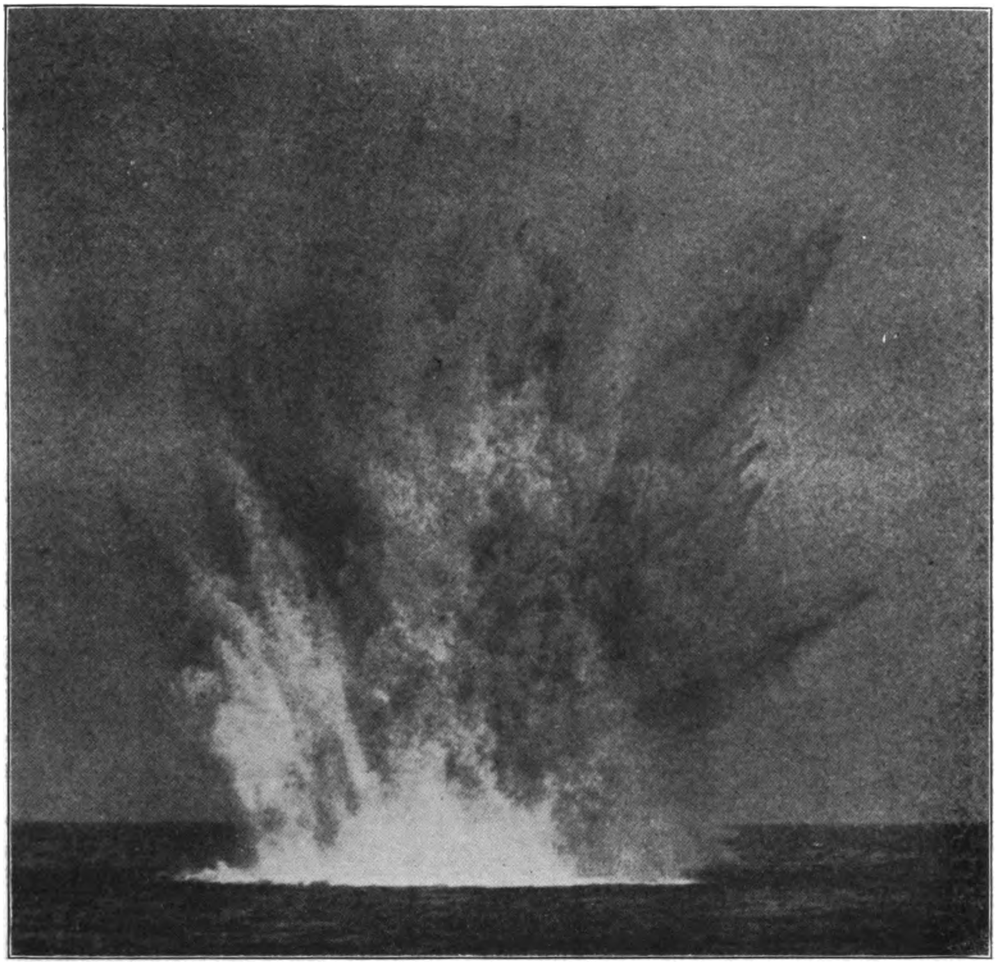
Section of Periscope

VENTILATION AND HABITABILITY

Space is always restricted in a submarine boat. When going on the surface the motor gives off much heat and requires a great amount of air for its combustion. It is unavoidable that some of the products of combustion, carbon monoxide and carbonic acid, leak out from the engine. Also the men consume oxygen and produce carbonic acid, and when charging the batteries free hydrogen is liable to be liberated, forming with the air in the boat an explosive mixture and carrying with it particles of sulphuric acid. Where the fuel is gasoline or other volatile oil, it will evaporate at a low temperature and is liable to leak out into the boat; it is poisonous and capable of forming an explosive mixture with the air. For these reasons, it is necessary to provide a very vigorous ventilation when going on the surface. In the submerged condition, the problem would appear to be even more difficult because the available air is gradually vitiated, but it is found that with proper precautions the crew can live for twelve hours or more without any sort of air renewal or means of purification. This is due to the constant leakage which takes place from the compressed air system, a leakage which can never be entirely prevented. If desired, the carbonic acid which gradually accumulates due to exhalation may be removed



Longitudinal Section of 18-inch *Mark II.* 5 Metre Whitehead Torpedo
Speed, 30 knots at 1,000 yards, 24 knots at 1,500 yards



Explosion of a Mine

by chemical means or the foul air may be pumped out. Fresh air can be supplied as desired from the compressed air reservoirs or pure oxygen may be added. There is, however, rarely occasion for resorting to such means except in case of serious accident. A greater difficulty is the escape of gasoline and poisonous fumes from the motor as well as from the battery. There is no convenient test for carbon monoxide suitable for use in submarine boats, whence it has been necessary to use white mice for indicating the presence of this poisonous gas to the effects of which these little animals are very sensitive. White mice breathe much more vigorously than human beings and will absorb carbon monoxide about twenty times as rapidly as man. Hence, long before man feels any discomfort, the mice will show symptoms of distress. When this occurs and, especially when the mice become asphyxiated, it is necessary to ascend to the surface and to renew the air in the boat.

Life on board a submarine boat is very fatiguing and for this reason the time in which a boat can stay away from its base is very limited. The crew has to be

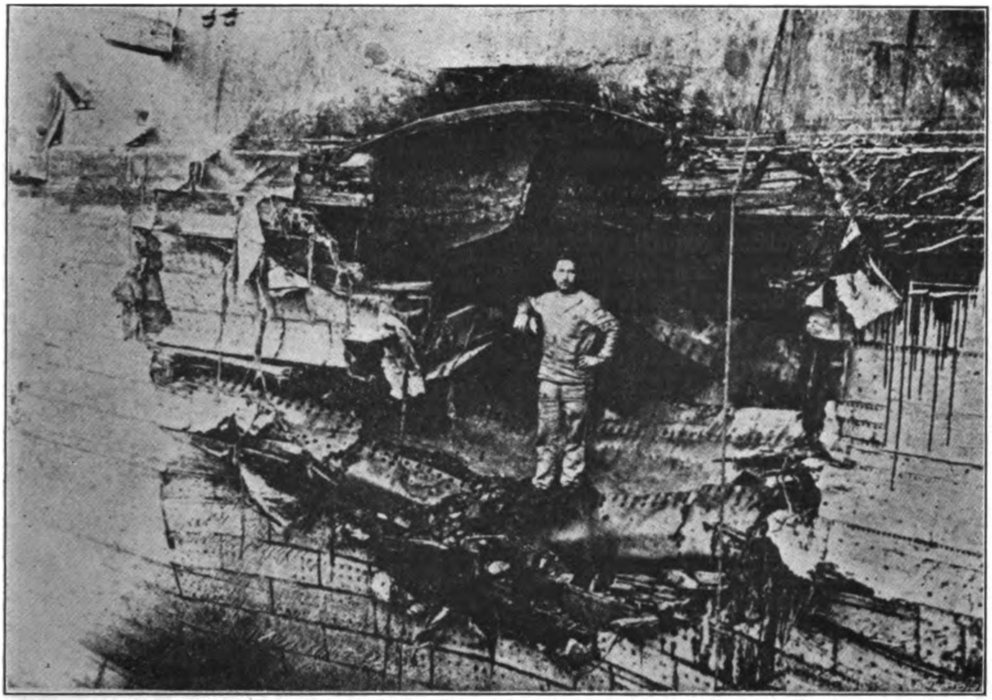
changed at frequent intervals or it must be given time to recuperate, a fact which in many cases may limit the practical endurance of the submarine boat more than the supply of fuel. Under war conditions the crew of a submarine boat ought probably to be relieved after a few weeks' service, depending of course on the size and design of the boat and on the climatic and military conditions.

PROPULSIVE MACHINERY

For propulsion on the surface the gasoline motor was the first really successful engine. It was light, occupied small space as compared with the steam machinery and the combustion of fuel oil was not more than about one-half pound per H. P. hour as against at least 1½ pound per H. P. hour for steam machinery. For small boats, of a displacement of from 100 to 300 tons, where weight and space were very restricted, the gasoline engine offered the best solution, but the dangers from this volatile oil soon made it necessary to introduce heavy-oil motors, although they were in several respects inferior to the gasoline motors. While the latter are easy to start, special means are required for starting the former, and the consumption of fuel in heavy-oil motors such as those of the Koerting type was about twice as great as in the gasoline motors. The last step in the development was the introduction of the Diesel engine which likewise burns heavy oil. Although in itself rather heavy, it has a consumption of fuel somewhat less than that of the gasoline engine, and this is its principal advantage. The nominal radius of action of recent boats of the largest size, driven by Diesel motors, is given as about 3,000 miles. The speed on the surface has attained 16 knots in several boats and the designed speed in some boats now under construction is 18 or 20 knots.

The Diesel engine, then, is the motor which today finds most favor in submarine boats, but with the increasing size of boats and the claims to higher speed it becomes increasingly difficult to produce motors of this type of sufficient power. Units of from 1,300 to 1,500 H.P. with a power per cylinder up to about 200 H.P. are under construction and there are usually two and in some boats three propellers. Many difficulties are met with and failures have occurred, whence steam power has been preferred in some boats as for instance in the French submersibles *Gustave Zédé* and *Nerëide* of 1,000 tons displacement, which are to make 20 knots. Steam machinery has the advantages of reliability and durability, but it occupies more space and it is difficult to get rid of the heat. The radius of action obtainable with steam power on a given supply of fuel is much smaller than with Diesel motors. The weight of Diesel engines as fitted in submarine boats is about 65 pounds per H.P. as compared with about 50 pounds per H. P. for gasoline engines and from 50 to 60 pounds per I.H.P. for steam machinery inclusive of auxiliaries, propellers, and shafts. The Diesel engine is being steadily improved and will no doubt be successfully adapted for larger powers in the submarine vessels of the future, but as the size and power increase, the relative advantages of steam machinery will become more pronounced.

For underwater propulsion, electric power derived from a storage battery of lead accumulators still offers the best solution. Since the first appearance of these cells they have been improved upon in many technical details, and are now reliable and durable. They will stand complete charging and discharging more than 400 times and may be expected to last about five or six years under ordinary service conditions in peace time, provided they are carefully handled. The weight per H.P.-hour including outfit is by discharge in 3½ hours about 80 pounds, practically the same as in the early accumulators. Lead cells permit great variations in power and are at their best at low rates of discharge, a most valuable quality for submerged work. They can be stowed low in the boat and add thus considerably to the stability. They occupy about .4 cubic feet per H.P.-hour, *i. e.*, less than any



Damage to Russian Cruiser *Pallada* by Torpedo Explosion

other source of energy at present available for this purpose.

Attempts have been made to introduce accumulators of different type, the most promising of which are the Edison alcalic iron-nickel cells which have now come into serious competition with the lead cells and are to be tested in practical service on board some of the United States submarine boats. Before the result of this experiment is known, it is difficult to judge of the relative merits of the two types. It seems certain, however, that the Edison cells are more durable but more costly than the lead cells.

The total accumulated energy by storage batteries is necessarily small and rarely allows more than a speed of about 10 knots for 3 or 4 hours. Recently boats have been designed for 11 or 12 knots. The radius of action at maximum speed of large boats is about 30 or 40 miles, but at reduced speed a radius of about 100 miles is claimed for some boats.

The electro-motors including switchboards and leads weigh about 80 pounds per H.P. The excessive weight of the plant for underwater propulsion is the more unfortunate, since the weight available for propulsion is already very small as compared with that in ordinary torpedo-boats. The reason for this is that the hull weight is relatively great, occupying about 10 per cent. more of the total displacement than in a torpedo-boat. Only about 40 per cent. of the displacement of a submarine boat can be devoted to machinery and fuel as against about 50 per cent. in a torpedo-boat. Moreover, the plant for underwater propulsion comes as an extra addition and is practically a dead weight when the boat is going on the surface. It is evident, therefore, that submarine boats can never compete with ordinary torpedo-boats in point of speed.

Great efforts are being made to devise a type of machinery that can be used both

on the surface and submerged and especially one by which the propulsion under water does not entail any extra weight, but no satisfactory solution has yet been obtained. Any process based on combustion involves the storage of atmospheric air or oxygen, but a storage of these gases in sufficient quantities for underwater propulsion requires excessive weight and space. The discharge of the products of combustion is liable to reveal the presence of the boat.

M. d'Equevilley has proposed a solution which is being tried in the French submersible *Charles Brun* and probably also in a German boat. He uses an ordinary boiler with oil fuel and a steam engine on the surface, but when the boat dives under water the exhaust steam is led to a concentrated lye of sodic hydrate which absorbs the steam under strong evolution of heat and thus serves as fuel in a secondary "soda boiler." This process goes on till the lye is saturated. When the boat comes to the surface and steam is available from the primary boiler, the soda lye may again be concentrated by evaporation of the water which it has absorbed, and the boat is ready for another submerged run. This plan offers the advantages that there is no change of propelling motor, the same engine being used under water as on the surface, and there are no products of combustion. The machinery can be forced without difficulty and relative y high power attained both in light and submerged condition. No electric motor is needed. On the other hand, the system requires the addition of special soda-boilers and a hot water reservoir; the plant occupies so much space that the available weight cannot be fully utilized; the center of gravity of the machinery is high and requires extra ballast to be carried; the radius of action on the surface is necessarily smaller than with an explosion motor; there is likely to be a strong corrosion of the boiler due to the soda, and isolation for heat will probably cause difficulties. The soda-boiler installation appears, nevertheless, more promising than other power plants so far proposed for this purpose.

ARMAMENT

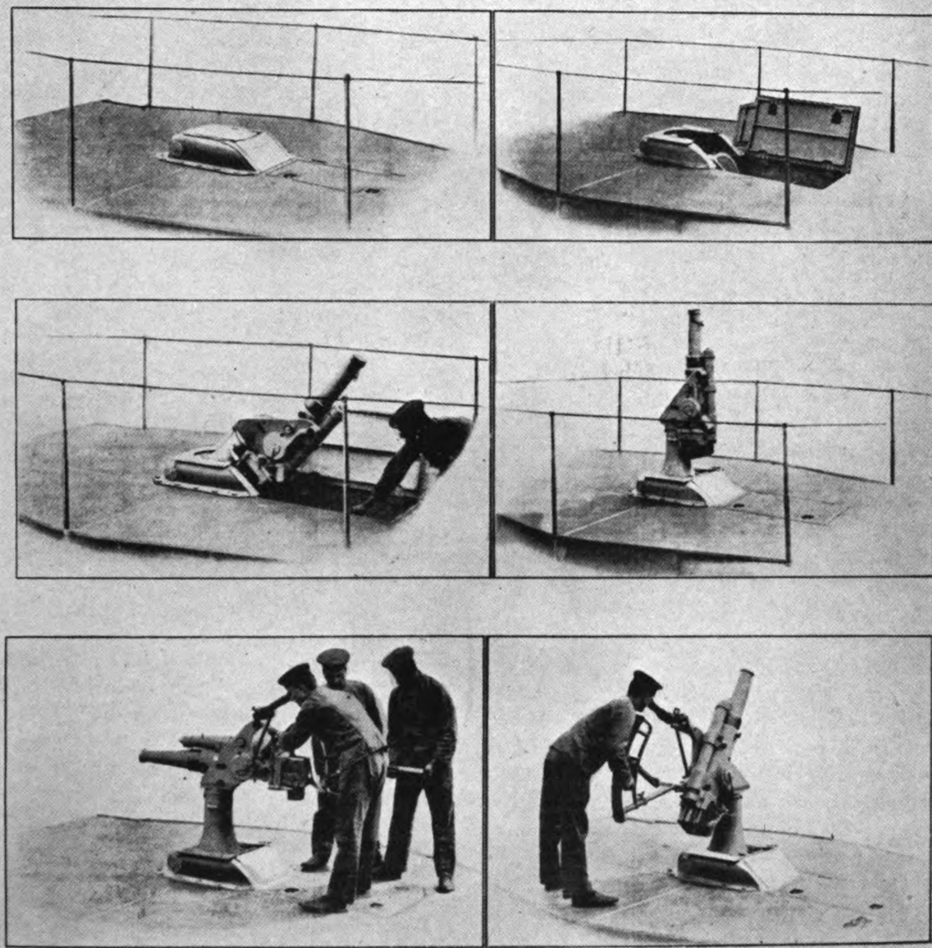
The principal armament of submarine boats is the Whitehead torpedo. Recent English boats are said to carry six 21-inch tubes and French boats of the latest type eight tubes. Modern large boats are equipped with an armament of light guns in disappearing mountings. English boats carry two 3-inch or 4-inch guns so mounted that they can be used against air-craft as well as against other vessels. When not in use the guns and mounts are housed in the superstructure.

Attempts have been made to design mine-laying submarine boats, a problem which is evidently of considerable interest. As far as known, Russia was the only power that, prior to the war, had built a boat for this purpose, viz., the *Krab*, designed for dropping mines when in surface condition. It appears that the Germans are now following the example of Russia. A boat so designed that mines could be dropped when in the submerged condition would be of greater value, but there are technical difficulties in releasing mines under water, in compensating for their weight and in determining their exact location. These difficulties have apparently not yet been overcome.

SIGNALLING

The faculty of communicating with other vessels whether on the surface or submerged is one of great military importance for the submarine boat. For service on the surface wireless telegraphy has been successfully used for several years, but for submerged service it is only quite recently that means of signalling have been devised which promise good results. It was at first, when the submarine bell was invented, attempted to use it for signalling, but it was found that it was not well adapted for sending messages by the Morse system. No practicable solution was discovered till an Austro-Hungarian physicist, Mr. H. C. Berger, showed the way by his experiments undertaken in the Danube at Buda-

DISAPPEARING GUN FOR SUBMARINE-BOATS.
CONSTRUCTED BY MESSRS. FRIED. KRUPP A.G., ESSEN (RUHR).



pest on the transmission of vibrations through water. A wire of two inches in diameter was set into longitudinal vibrations by the friction of a hand-driven silk-wheel moistened with alcohol whereby a clear and sustained note was produced, capable of being sent in dots and dashes of the Morse code. The wire was fastened to a plate in contact with the water, and was anchored at the other end to some fixture. The tension of the wire was immaterial. The identical apparatus used by Berger was fitted in one of the United States submarine boats in 1911 and readable signals were transmitted over a range of two miles. Still better results were obtained with steel ribbons and power driven exciters, by means of which distinct signals were transmitted over a distance of ten miles. Recently electrically worked oscillators developed by Professor R. A. Fessenden, have been used instead of the wire ribbons and have given very promising results. This mode of signalling is referred to as the "submarine wireless system," but it must be

distinctly understood that the transmission through the water takes place entirely by sound waves emanating from a diaphragm plate which may form part of the ship's side. The receiver is a similar plate in another ship similarly connected. The invention seems now to have passed the experimental stage and signals have been transmitted under water without difficulty through a distance of fifteen miles. It is well described by Commander F. L. Sawyer of the United States Navy in a paper read last December before the Society of Naval Architects and Marine Engineers in New York.

SAFETY, SALVAGE, AND TRANSPORTATION

As a consequence of the numerous and serious accidents which have befallen submarine boats of recent years much has been done to increase the safety of this craft. The hull is subdivided more minutely than formerly by bulkheads of sufficient strength to withstand the maximum water pressure. A buoy provided with telephone connection is fitted in the superstructure and can be sent to the surface in case of emergency, enabling communication to be established with the outside world. In some boats the men are provided with diving suits and helmets enabling them to escape or to remain for a longer time in the boat when it is flooded. Great precautions are taken to prevent the fumes from the storage battery from entering the working rooms of the boat. The battery is in many boats placed in an entirely separate airtight well-ventilated compartment.

Vessels of special type, "salvage docks," are built for the purpose of raising the boats when they have sunk to the bottom in damaged condition. Shackles are fitted on the top of the boats for this purpose.

Special vessels are constructed also for the transportation of submarine boats.

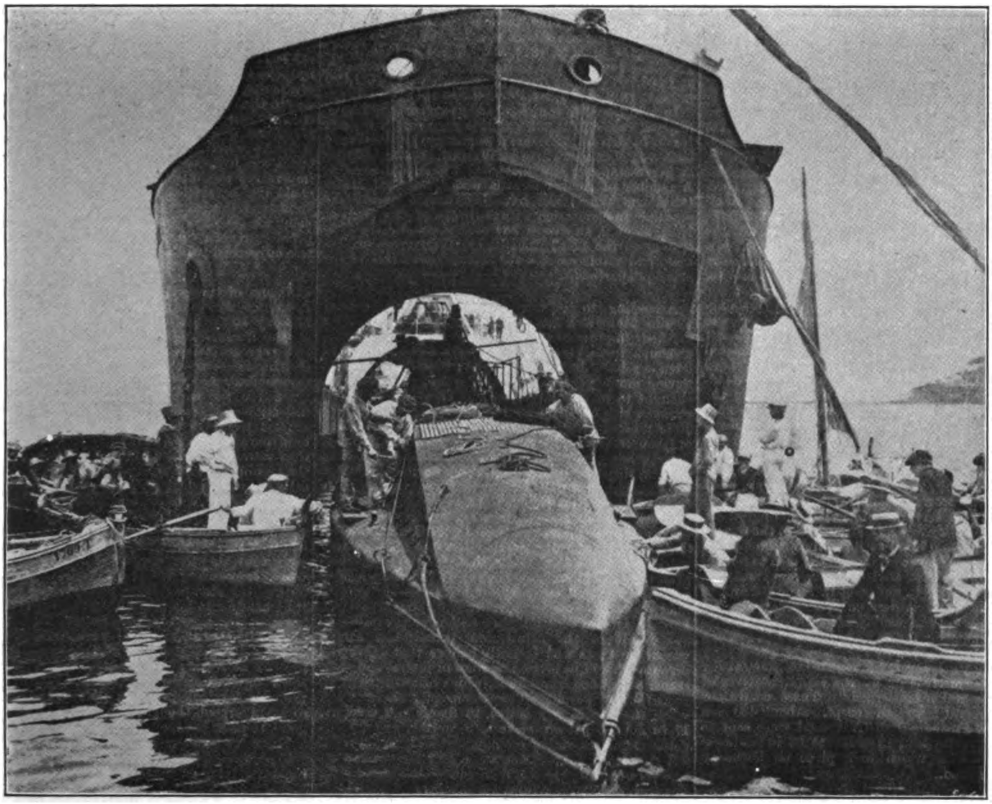
SIZE AND COST

From the moment that submarine boats were taken into practical service, claims to increased sea-going capability, speed, radius of action, and better living conditions on board were advanced by the naval officers. Those claims could be best met by an increase in size and we can understand, therefore, that size has steadily increased ever since the beginning of the century. Boats were then less than 100 tons fully submerged and are now being built of about 1,200 tons' displacement. The reason why the displacement has not increased much faster is chiefly the difficulty of providing suitable motors for propulsion of sufficient power. By an increase in size, moreover, the boats become more difficult to handle under water especially where the depth is small, but this difficulty is of secondary importance for ocean-going boats, which are likely soon to become a reality. The high cost of large boats will restrict their number, the price per ton being almost three times as high as for battleships.

MILITARY VALUE

The great military value of submarine boats has been demonstrated in the European war. At the present stage of development submarine boats afford not only the best means of defence of one's own harbors and coasts, but may be used also for offensive purposes in the open sea and on the coast of an enemy up to a distance of at least five hundred miles from their base. The large boats of from 1,000 to 1,200 tons' displacement now under construction will have a still greater effective radius of action.

It is characteristic for the submarine boat that, once it has gotten into position, it can carry out an attack with relatively small risk to itself. In this respect it differs radically from ordinary torpedo-boats which must be prepared for great and almost unavoidable sacrifices in order to carry out a successful attack. The greatest difficulty with a submarine boat is to bring it into position for attack because the speed is relatively slow. The initiative of the commanding officer, the training, endurance, and discipline of the crew as well as the condition of the boat and the machinery



The *Kangouroo,* French Transport Ship for Submarine Boats

count more in submarine boats than in other warships.

The development of the submarine boat in the future is likely to be gradual. In the meantime, it is probable that also the means of attack and defence possessed by the battleship against submarine attack will progress. Evidently, the first point for the battleship is to detect the submarine boat before it has reached within striking range. If this is successfully accomplished, the attack of the submarine boat can generally be avoided because its speed under water is relatively slow. Detection of a submerged boat is, however, a difficult matter, the only visible point being the head of the periscope which needs to be shown above the surface only from time to time. In still water the periscope is fairly visible by the wake which it makes on the surface when emerging, but in rough and misty weather it is extremely difficult to see. When the periscope is discovered, it will be at once subject to a hail storm of projectiles from light guns and, if it is hit, the boat will be blind and helpless. If, after that, the boat shows the conning tower above the surface, it will be generally exposed to destruction by artillery fire.

Detection from seaplanes and other types of air-craft is under many circumstances fairly easy and this mode seems to promise a great deal. These new engines of war may possibly become deadly enemies of the submarine boat by attacking it with bombs. When a boat is submerged it is quite helpless against such

attack. Even very light bombs are likely to prove destructive, and since the air-craft is in no danger of counter-attack from the submarine boat, it can go very low and hitting should not be a difficult matter. The submarine boat cannot even observe a seaplane when immediately over it. A further development of the seaplane is, therefore, likely to prove extremely dangerous to the submarine boat.

While the active or offensive means of defence are in this case as elsewhere the most effective, the battleship possesses means of defence of a passive nature such as watertight subdivision, elastic bulkheads and underwater armor, which may still be further developed, but experiments and war experience are required to throw light on the problems involved. The superior speed of battleships is of course in itself a means of protection. On account of the present limited range of submarine boats and perhaps especially on account of the limit to the endurance of the personnel, they do not render the powerfully armed and well-protected artillery ships superfluous. Fast sea-going battle-ships or battle cruisers are yet required in order to control the ocean, but as matters stand now, the smaller enclosed seas such as the Baltic, the North Sea, the British Channel, the Mediterranean, the Yellow Sea and other similar waters, may practically be controlled by submarines and by light, fast vessels. In the presence of an active enemy well provided with submarine boats large vessels cannot operate in such seas except under the greatest precautions, going at high speed and using all possible means for their defence. Merchant vessels fall an easy prey to submarine boats in such waters, their subdivision—even in the largest and best designed vessels—falling far short of that of warships.

VALUE OF OUR MINERAL PRODUCTS

According to the United States Geological Survey the value of the mineral production in the United States now exceeds $2,500,000,000 a year. This value, although falling far below the farm products of the country, can best be measured by comparison with other countries. The United States mines nearly 40 per cent. of the world's output of coal, and produced 65 per cent. of the world's petroleum in 1913. Of the world's more important metals 40 per cent. of the world's output of iron ore comes from American mines, and the smelters of the United States furnish the world with 55 per cent. of its copper and at least 30 per cent. of its lead and zinc.

HEAT TREATMENT OF COPPER AND BRASS

A CONTROLLABLE PROCESS IN THE PREPARATION OF THESE METALS WHICH VARIES THEIR PROPERTIES AND GIVES THEM A WIDE FIELD OF USEFULNESS

BY CARLE R. HAYWARD

THE mechanical properties of pure metal depend on three factors: First, general qualities inherent in the metal; second, properties imparted by mechanical treatment, such as rolling, drawing or forging; third, properties imparted by heat treatment, that is, heating to various temperatures and cooling at various rates. The first of these three factors admits of no discussion; copper can never be made the same as iron or lead, however it may be treated. The other factors are controllable and are of vital importance, for they may ultimately determine whether a metal is valuable or worthless.

What has been said above regarding metals is equally true of alloys, the usefulness of which depends not only on the composition but in many cases to a great extent on the mechanical work and heat treatment to which they have been subjected.

It is the purpose of this paper to discuss in a general way the effect of heat treatment on copper and one of its most important alloys, brass.

COPPER

Copper when cast has the crystalline structure characteristic of all cast metals. The arrangement of the crystals known as casting structure is due to the fact that the metal first solidifies at the outside, and the center is the last portion to become solid. Furthermore, the solidification and subsequent cooling have been so rapid that the crystals are likely to be in a state of strain. This radical arrangement of the crystals and their strained condition make the casting liable to break when subjected to severe stress. When copper castings are heated bright red a rearrangement of the crystals takes place and internal strains are relieved, thus improving the mechanical properties of the metal. By far the larger part of the copper in general use has been subjected to some mechanical work such as forging, rolling into sheets, or drawing into wire. This treatment hardens the metal and greatly changes the internal structure, by crushing and elongating the crystals. Fig. 1 shows a photo-micrograph of a piece of soft copper. The structure is developed by dipping in acid. Some crystals are attacked more than others and thus appear dark. After rolling, it had the appearance represented in Fig. 2. Note how the crystals have been distorted and crushed.

For many purposes it is desirable to retain the copper in the hardened state in which it exists after mechanical treatment, but in other cases soft and ductile material is preferred. Fortunately this state can be restored by annealing the metal at a bright red heat (about 700° C. or 1290° F.). This softening is accompanied by a decided change in the structure of the metal as shown in Fig. 3. It will be noted that the fractured particles of the original crystals have formed into new crystals and the material presents an appearance similar to the original structure before rolling. The size of the crystals depends on the temperature to which the metal is heated and the time it remains in the furnace. This is well illustrated by Figs. 4 and 5 which show the growth of crystals with temperature.

Quenching copper in water has a softening effect, the cause of which is not fully understood. Unlike steel, copper cannot be hardened or tempered by any method of heat treatment. The so-called lost art of tempering copper is a myth. Analyses of ancient copper implements show that they are in reality alloys of copper with

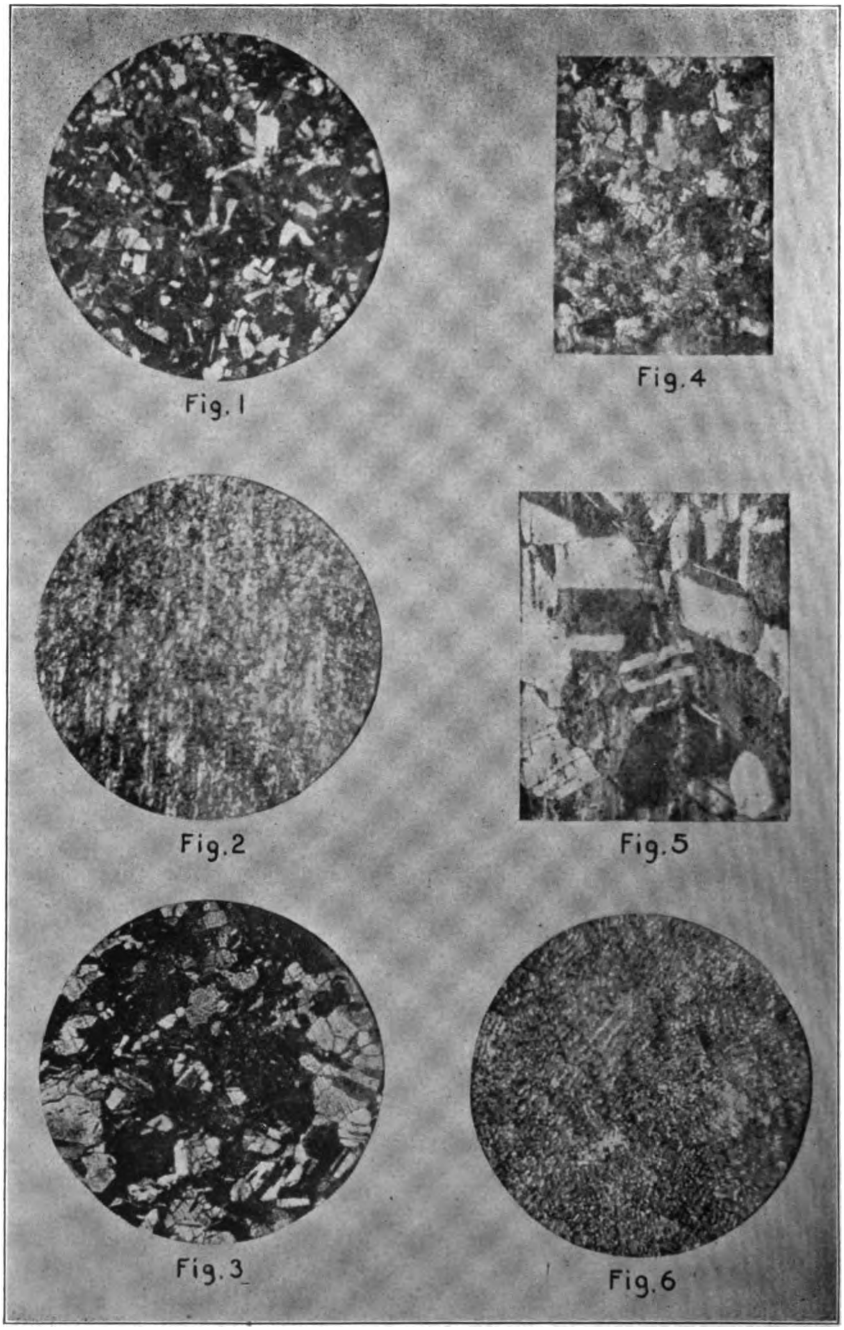


Fig. 1.—Annealed Copper.
Fig. 2.—Rolled Copper.
Fig. 3.—Rolled Copper Annealed at 750°C (1382°F).
Fig. 4.—Rolled Copper Annealed at 650°-700°C (1200°-1290°F) for 40 minutes.
Fig. 5.—Rolled Copper Annealed a short time at 900°C (1650°F). **Fig. 6.—Cast Brass.**

tin, arsenic or some other element which occurred mixed with the copper ore and became alloyed with the metal during the crude smelting operations. These substances have a hardening effect on copper and the hammering process by which the alloy was beaten into the desired form increased this property.

It is seen therefore that the heat treatment of copper is a simple process which consists in heating the metal to a bright red color thereby removing strains or hardness produced by mechanical work. Temperatures above 800° C. (1470° F.) should be avoided as the crystals become large and the metal is weakened.

The only way copper can be hardened is by alloying it with some other element or by rolling, drawing or forging it.

BRASS

Brass is an alloy of copper and zinc with sometimes small amounts of other elements to give it special properties. The relative amounts of copper and zinc vary in different brasses but except for special purposes the copper is between 55 and 70 per cent., and the zinc varies accordingly. When the copper is above 63 per cent., all the zinc present remains dissolved in the copper, and the solid alloy has a homogeneous structure with the general properties of a pure metal. When, however, the copper is below 63 per cent., the solid metal, when slowly cooled, contains two components, one of which is brittle and makes the alloy undesirable for many purposes.

Much that has been said regarding the heat treatment of copper is equally true of brass. Fig. 6 shows the microstructure of cast brass and Fig. 7 shows how the crystals have rearranged themselves on annealing. As in the photographs of copper previously discussed, the different shades of crystals are not due to differences in composition but to different degrees of etching. The growth of the crystals takes place in the same way as that of copper crystals. This is illustrated by Figs. 8–16. Fig. 8 shows the structure of a brass with 67 per cent. copper after annealing and Fig. 9 the structure of the same material after rolling. The effect of temperature on the growth of crystals is shown by Figs 10–12. The effect of time on the growth of crystals at constant temperature is illustrated by Figs 13–16.

Brass is hardened by rolling or drawing and softened by annealing. Spring brass is given its properties by rolling and would lose them by annealing. The rearrangement of crystals in rolled brass begins at 420° C. (788° F.) which is below the faintest red heat. Between 600° and 700° C. (1110° and 1290° F.) all internal strains and hardness are removed.

Care must be exercised when heating brass, not to allow the temperature to exceed 800° C. (1470° F.) as there will be danger of volatilizing some of the zinc contained in it, leaving the alloy porous.

The quenching of brass containing more than 70 per cent. copper makes little difference in its mechanical properties. With smaller amounts of copper, especially between 50 and 63 per cent. the slowly cooled metal is more brittle than the chilled material. This is due to the fact that chilling prevents the separation of a brittle compound of zinc and copper.

The above facts about copper and brass show that the heat-treatment of these materials is a simple matter compared with the treatment of steel, where slight differences in the temperature, time of heating, and rate of cooling may produce widely divergent results. If the steel has been overheated but not "burnt" the coarse structure obtained can be removed by reheating to a lower temperature. In the case of copper and brass, heat-treatment is merely annealing and the rate of cooling, except with brasses containing less than 65 per cent. copper, is of comparatively slight importance. If the structure is coarse, due to heating too long or at too high a temperature, the metal cannot be refined by reheating but must be subjected to rolling, hammering, or drawing which will break up the crystals. Reheating to the proper temperature will then soften the metal and relieve the strains.

In general it is true that fine-grained material is mechanically superior to that with coarse grains. For this reason care should be taken to anneal copper and

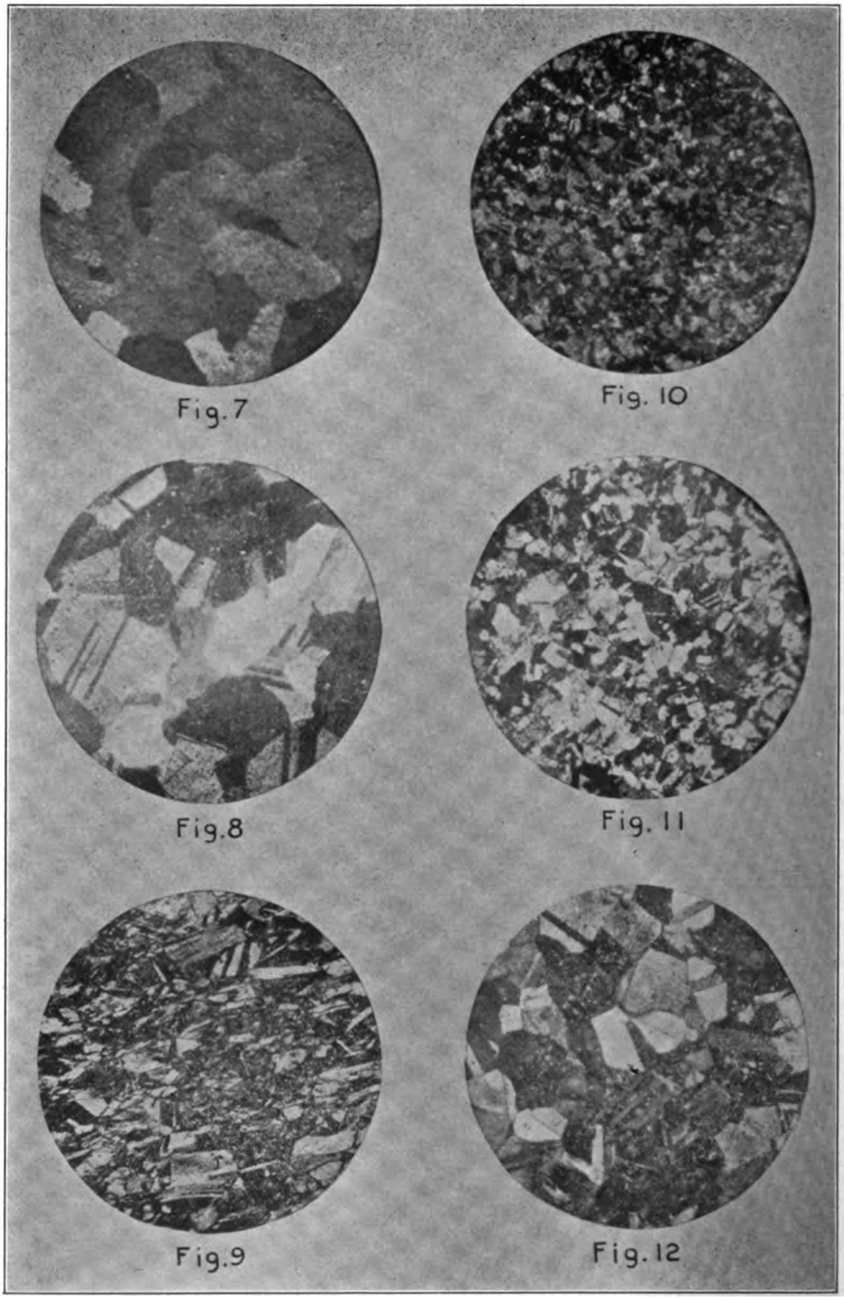


Fig. 7.—Cast Brass Annealed.
Fig. 8.—Annealed Brass.
Fig. 9.—Brass of Fig 8 rolled.
Fig. 10.—Brass of Fig. 9 annealed 50min. at 425°C (797°F).
Fig. 11.—Brass of Fig. 9 annealed 50 min. at 500°C (930°F).
Fig, 12.—Brass of Fig. 9 annealed 50 min. at 600°C (1110°F).

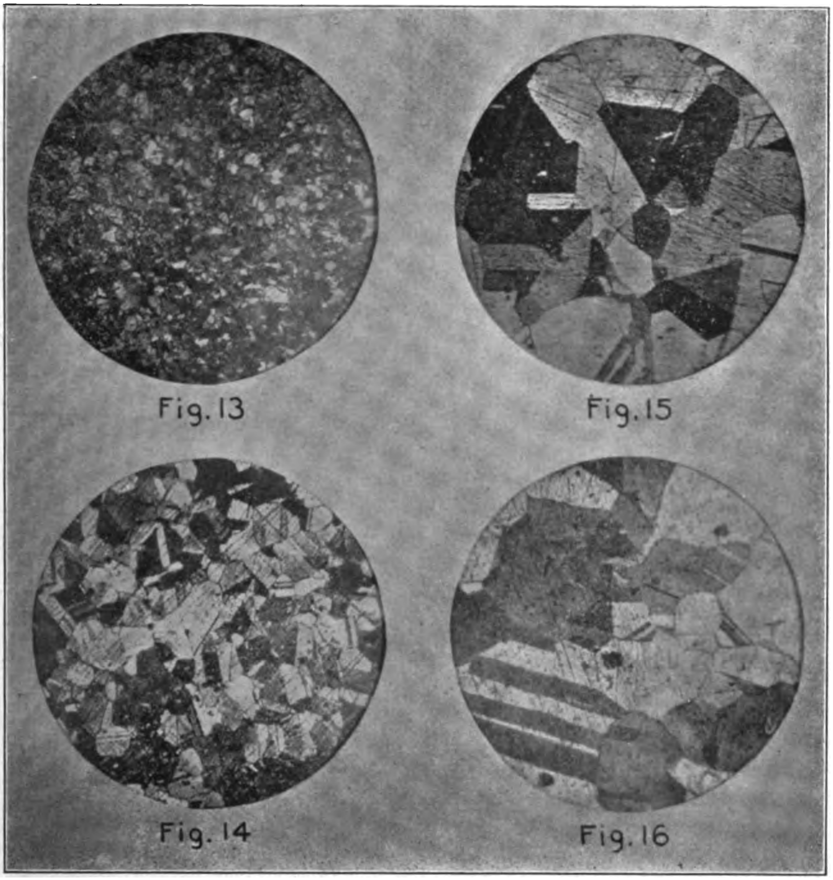


Fig. 13.—Rolled Brass annealed at 650°C (1200°F) for 15 seconds.
Fig. 14.—Rolled Brass annealed at 650°C (1200°F) for 40 seconds.
Fig. 15.—Rolled Brass annealed at 650°C (1200°F) for 2 minutes.
Fig. 16.—Rolled Brass annealed at 650°C (1200°F) for 15 minutes.

brass at the lowest temperature which will relieve the strains due to mechanical work. Higher temperatures will produce larger crystals. The proper temperature varies somewhat with brasses of different composition but, except in special instances, for either brass or copper, should not exceed the temperature given above (700° C.) and in most cases a lower temperature (600–650° C.) is preferable.

When it is desired to remove only part of the hardness the copper or brass may be annealed at a dull red heat for a short time, and even heating to a temperature just below dull red will sometimes suffice.

PROCEEDINGS OF THE ACADEMY

The Proceedings of the National Academy of Sciences, which first appeared in January, and of which the managing editor is Prof. E. B. Wilson of the Institute, has recently taken rank among the few indispensable scientific journals of the country. The aim of the journal is to furnish a comprehensive survey of the more important results of scientific research of this country.

Prof. A. A. Noyes, '86, and Dr. George E. Hale, '90, are connected with the publication of the journal.

THE NEWEST COSMOGONY

SUGGESTIONS BY DR. PERCIVAL LOWELL TOWARDS A WORLD ORIGIN THAT ACCORDS CLOSELY WITH THE KNOWN FACTS OF TODAY

BY JOHN RITCHIE, JR.

AN EXCEEDINGLY interesting development from the work at the Lowell Observatory, Flagstaff, has been the setting forth of a new cosmogony by Dr. Percival Lowell. The purpose of the institution is for planetary observation, and while the intensely interesting announcements with reference to Mars have commanded the attention of the world, astronomical and layman, and have suggested to many that Lowell is mostly an observatory of Mars, this is by no means the case, and the other members of the solar system have constantly been watched. Some very interesting discoveries have been announced with reference to motions and appearance of the companions of the earth in the universe. It is but natural, therefore, that Flagstaff should have been greatly interested in the origin of the solar system.

The last few years have been fruitful ones in the development of hypotheses concerning the origin of suns and worlds. For a long time the ideas of LaPlace reigned supreme, but next there came a period of unrest with continual castings about for new suggestions that would accord with the newer facts. There was the planitesmal hypothesis of Moulton and Chamberlain, the segregation suggestion of Dr. T. J. J. See, variants on both of these, a return by Arrhenius to a position much nearer that of LaPlace and now that of Lowell, which in certain ways is different from any of the others.

The statement in brief of the Lowell hypothesis is this: The planets grew out of scattered material. Each one brought the next one into being by the perturbations that it caused in the scattered material at definite distances from itself, being, so to speak, the elder sister of the newer planet. Of the major planets Jupiter was the starting point and after it was formed there came Saturn, then Uranus and Neptune. The same is true of the minor planets, each being formed in turn in a place determined by the others. To use Dr. Lowell's own words, "The positions of the planets are not haphazard, but have been determined seriatim each by its predecessor, thus showing that the solar system is an articulated whole, an inorganic organism, which not only evolved, but evolved in a definite order, the steps of which celestial mechanics enables us to retrace."

What LaPlace taught was a bequest from the eighteenth century to the nineteenth, having been formulated with some diffidence during the closing quinquennium of the former. For nearly a century it satisfied reasonably well the needs of astronomers. The Nebular Hypothesis, for that was its usual name, had not any thought about origins in their more modern sense. It referred the solar system to no stellar collision, but merely assumed that there existed in the place where it afterwards formed a vast mass of glowing gas. This was more or less pancake in shape with a central condensation where the sun is now. The nebula was rotating and slowly cooling. In the shrinking process rings of material were formed and left at distances from the center which were approximately those of the planets of today, and these rings presently lost continuity and rolled themselves up into balls, the planets. The planets, masses of glowing gas, were themselves subject to shrinkage as they cooled and rings of matter were left behind which when they broke formed spheres, the existing satellites.

The unfortunate part of this hypothesis, according to Dr. Lowell in one of his

lectures half-a-dozen years ago, is that, while the facts known at the time were quite well cared for, the facts that have come to light since the hypothesis was formulated are most difficult to manage. In fact he voiced the opinion that if LaPlace were now alive and attacking the same problem in the light of modern knowledge, he would give a very different answer. There has been wide dissatisfaction in many quarters with the hot nebula, and astronomers have been more and more in favor of a cold origin for the earth. Then again there have been some who are bold enough to affirm that mechanics will not permit such a ring to roll up into a ball.

Ten or a dozen years ago, two Chicago men, Moulton and Chamberlin, put forth a hypothesis which attracted much attention and has today numbers of supporters. This goes back a step or two in origins and begins with a spiral nebula, the supposed cause of which was the collision or near approach of two great stars. The strains of a near approach would disrupt the two bodies and for a result two arms of loose material would be thrown out not unlike the rays of a slowly moving pinwheel. As would naturally ensue, the distribution of material would not be even and there would be knots or condensations here and there in the arms. As the result of the close approach the mass would have a motion of rotation about its centre of gravity. The knots would naturally draw to themselves through gravitation the material in their vicinity, and, in the revolutions, would really sweep the sky clear of the stardust that had been left there by the collision. There would of course be a constant rain upon the planetary surfaces of the loose material and the planets would grow in size. The smaller knots, which had sufficient independence to remain unconfiscated are the satellites and they, as well as the planets, have taken part in the clearing of the region of débris.

The pressure of the material that has come to the surface of any planet would of course generate heat and sufficient to account for the igneous phenomena of geology. The hypothes's is interesting for it makes a new geology in which the gradual cooling of the earth from a mass of glowing gas is to be found no more; atmospheres of carbonic acid gas are dispensed with and from the very beginning there have been sunny skies, gentle showers and meteorological conditions not very different from those the earth now experiences. And coming to the aid of the hypothesis, some geologists have found raindrops and other supporting records in the very earliest of the sedimentary rocks.

Something like four years ago Dr. Lowell made the first report of what his observatory has been doing in cosmogonies, and suggested one founded on the spiral nebula, with tidal action for the force that has gradually been reversing the poles of the planets, complete in the inner ones and in progress in the outer ones. But he had little sympathy with the cold process and claimed that it was a hot earth that is now cooling and that the major planets are still exceedingly hot.

Then in 1911 Dr. See set forth his views in a bulky volume. He outlined the situation and noted that there were only three solutions to the general problem: Detachment from a central body, which was what La Place had suggested; the capture by the sun of the planets already made, and the formation of the planets just where they are by aggregations of cosmical dust. These, he boldly says, are all the suppositions that it is worth while considering with reference to the formation of the solar system.

Dr. See next shows the impossibility of the Nebular Hypothesis, bringing in almost legal form seven or eight allegations against it. The details of his own suggestion can hardly be given in full here, but in brief the process is the forming of numberless spheres within the dust of a nebula, which in quantities went to the building up of the larger spheres. Myriads of them as large as the moon built up the sun, while the planets grew by accession of spheres already formed and not by the profuse rain of meteoric particles as held by the Chicago men. There was a good deal that was revolu-

tionary in the setting forth of Dr. See. He does not believe that the earth and moon were ever hot, or that the craters of the moon were ever really volcanic, and thinks that the earth must have had similar indentations, the record of the impact of some of the spheres already formed, but that they have been obliterated by the ocean. See will not agree with W. H. Pickering that the moon ever was part of the earth. "It is a planet," he says, "which came to us from the heavenly spaces and similar captures occurred in the cases of other satellites."

Then came Arrhenius, who, in a course of Lowell lectures three or four years ago, presented rather conservative opinions. He is, to a considerable extent, a supporter of La Place, but finds his planets in great comets or dark spheres that came from space, penetrated the solar nebula, became enmeshed in it and have settled down to regular, orderly orbits about the sun. Of course they have had their part in sweeping the space of its nebula. Unless Dr. Arrhenius was misunderstood at his Boston lectures, he claimed that the moon and other satellites were secondary captures of comets, being taken not by the sun but by the individual planets which hold them.

In his cosmogony Dr. Lowell now begins not with the spiral nebula but with the planetary form. In the former there are two great arms, the results of the stresses of near approach, and there are knots or condensations in them which are what some believe to be the nuclei about which the planets form. The planets grow by gathering to themselves the fragments of nebula lying near their paths. An objection to the spiral nebula suggestion, according to Dr. Lowell, is that such an origin would be likely to produce planets in pairs on account of the probable symmetry in the knot-positions in the two arms. On the contrary the original solar system nebula must have been of the so-called planetary form with a central condensation, a fairly even distribution of material and a motion of rotation. Everything is here in motion, the central condensation which is to develop into the sun and the particles of the plenum, the latter, indeed, having each one its individual revolution about the center of gravity of the whole mass.

But the distribution never by any possibility can be even, so that there will infallibly be local gatherings of material. Any one of these will exercise influence over the particles in its vicinity, drawing them to itself if they are near and collecting them in all parts of the orbit, so that the sweeping of the path of the growing planet will be effected. The sweeping will be done throughout a zone within which the attraction is sufficiently strong to bring the particles to the planet.

Outside this region the attraction will effect a perturbation of the particles, which, while disturbed somewhat, will continue in nearly their former orbits. The effect of the perturbation must be to introduce an influence, perhaps best expressed as a "jostling," which causes the particles to collide, to interfere with one another's motions, to lose headway and in short to gather a group of particles which will form the nucleus of a new planet.

This is what Dr. Lowell means when he says that "so the process goes on, each planet acting as a sort of elder sister in bringing up the next." As soon as a planet is formed, it begins to call into being another one beyond it, and the latter could not begin earlier because the fundamental factor, the perturbation of its predecessor, was lacking.

The mathematics to support his position are given quite at length by Dr. Lowell in his original presentation,* attention being given to certain potent periodic rates, $^1/_2$, $^2/_5$, $^1/_3$, expressive of the mean motion, and suggestive of proportional commensurability in the major axes of the orbits of the planets.

In an interesting way, Dr. Lowell presents some of the arguments in favor of his hypothesis. He adduces the fact that the planets are not in their precise computed places, but to sunward of these as an additional argument, showing the existence of similar perturbations of a different order. He finds also that the

* Memoirs of the American Academy of Arts and Sciences, XIV, 1.

asteroids point "unmistakably" to such a genesis, missed in the making. Jupiter lies very close to the original starting point of the planetary evolution and was the first of the planets to form. If Neptune had been the first, it would now have the greatest density, followed by Uranus, Saturn and Neptune; whereas the densities are now in the opposite order, save that Saturn has a low figure. Dr. Lowell finds further that the inner planets support his rule of commensurate period points and dovetail into the major ones through the $^2/_5$ relationship between Mars and the asteroids.

SPRAYED METAL COATINGS

During the last two years a new method of producing a thin coating of metal on miscellaneous articles has been perfected that has possibilities beyond any previous methods. The apparatus which is used in producing this coating is on the principle of an atomizer. The metal with which the object is to be coated is introduced into the machine in the form of a wire. It is melted by mixed gases, and at the same moment is blown upon the object to be coated by a blast of compressed air. The molten metal is carried from the spraying machine in a finely comminuted molten condition and is fixed upon the object in a smooth, compact surface adhering tenaciously to the surface and penetrating into the most minute crevices. The method is known as the Schoop process.

The metals that have been tested with satisfaction are lead, tin, zinc, aluminium, brass, copper, bronze, nickel silver; while gold and silver, although amenable to the process, have not yet been fully exploited. The film deposited by the spray may be as thin as one one-thousandth of an inch.

Some curious phenomena have been brought out by this process. While the temperature at the apex of the cone of the spray may be 700° to 2000° F., at a distance of three, four or five inches away, combustible materials may be coated with the metal without danger of being burned. The heads of matches can be metalized by the Schoop process without being ignited, tissue paper can be surfaced with it, and the finest silk has been metalized without injuring its texture.

AIR TO THE RESCUE

An interesting and novel method of floating a ship that had forced herself into the mud nearly three feet above her light-load line was used on the steamship *Zeeland* in the St. Lawrence River. Two holes were bored in the inner end of fourteen brass drainage plugs which were already in the ship's bottom plating, having been put in from the outside. Key wrenches were fitted into the newly drilled holes and the plugs were released by unscrewing them outward. Threaded pipe connections were instantly screwed into the holes, and a rubber hose leading to an air compressor was attached. Then a stout wire hawser was looped around the bow of the liner, each end being led to a securely moored dredge where it was passed around the drums of powerful winches. In addition lines were led to tandem tugs, representing 14,000 horsepower. The ship was lightened all possible and then the compressors were put to work. The escaping air broke the seal between the bottom of the vessel and the adhering mud, and in a very short space of time the liner was towed off into deep water.

NORTHEAST STORMS

Many of our readers will be surprised to learn that what we know here in the East as northeast storms do not in reality come from the northeast at all. The storm itself comes from the west or southwest, usually along a well-recognized track, and the strong northeast rain-bearing winds, which drive the rain to the ground as from a northeastern direction, are simply the indraft of a barometric depression in the reverse direction. It is very rare that a storm in these latitudes travels from the East to the West. Such storms are called "flarebacks" and are the despair of weather forecasters.

PLANTS AND ANIMALS DISTINGUISHED

HAD we been given the problem of starting life upon the surface of this earth, our first care, after receiving the impetus with which to set life moving, would be to get a source of energy which could be stored in reservoirs suitable for tapping at will. We would soon find the only practicable source to be the light of the sun. The problem then would be to convert the sun's rays into a form suitable for storing and tapping at will. This problem life has solved through the agency of chlorophyl, the green coloring matter of plants. This chlorophyl is the factory in which the sunlight works, breaking up the CO_2 into C and O, and recombining these atoms with some products derived from the soil into starch. In other words, the kinetic energy of the sun's rays is transformed into the potential energy of starch and in this form becomes the reservoir capable of being tapped at will for movement, reproduction, or other needs. There is considerable reason for believing that an early form of life combined in itself the power of storing up energy and of expending it in free movements. For some lowly forms, such as the free-moving, microscopic, one-celled organism Euglena, still exist which through the presence of chlorophyl are enabled to manufacture starch.

In such a form the plant and animal kingdoms merge their characters to such an extent that it is impossible to classify it as definitely either plant or animal. Similarly upon hardly any other theory than the former union of the plant and animal kingdoms can we account for the difficulty of making a definition for the one which will be exclusive of the other. There are exceptions to almost every statement made in defining them. If, for example, we arrange such definitions in parallel columns this conclusion will be easily seen.

PLANTS

1. Take food from the inorganic and convert it into organic, as starch, proteids, etc. (Exceptions—fungi, bacteria, etc., live upon organic material.)
2. Chlorophyl present. (Absent in many parasitic forms as dodder.)
3. Cellulose present.
4. Without power of locomotion. (Spores of some algae have locomotion and contractility but later become fixed. Many higher plants, as honey locust, clover, etc., have contractility prominently developed.)
5. Eat by absorption.
6. Make use of CO_2 and some oxygen.
7. Excrete O, and CO_2.
8. Have no definite number of organs.
9. Have unlimited growth (except many fungi, etc.).

ANIMALS

1. Feed upon organic matter.
2. Chlorophyl absent. (Present in some protozoöns.)
3. Cellulose absent. (Present in some protozoöns and very abundant in the ascidians.)
4. Locomotion more or less free.
5. Have mouth and digestive canal. (Some very low or degenerate forms eat by absorption.)
6. Make use of oxygen.
7. Excrete CO_2 and urea.
8. Have definite number of organs.
9. Have limited growth (except many sponges, corals, etc.).

To this may be added that both plants and animals respond to external stimuli, are affected by narcotics, become fatigued after repeated stimuli from which they recover upon rest, sleep once a day and upon death cease exhibiting these conditions.

If, as this similarity makes probable, both organic kingdoms were at first united in a generalized type capable both of storing energy and of expending this energy in free movements, this union within the same individual was soon found to be incompatible and part of these generalized organisms, which were neither plant nor animal, chose the line of energy storing and part that of using this stored up energy in free movements; the former developed into the Vegetable Kingdom, the latter into the Animal Kingdom.

It is better then to define these two kingdoms, through the characters upon which each lays special emphasis. Plants lay emphasis upon immobility, animals upon mobility. If the two kingdoms are thus defined with the attendant consequences, the following diverse conditions result. Plants in choosing the life of energy-storing were sure of their food but as a result they became immovably at-

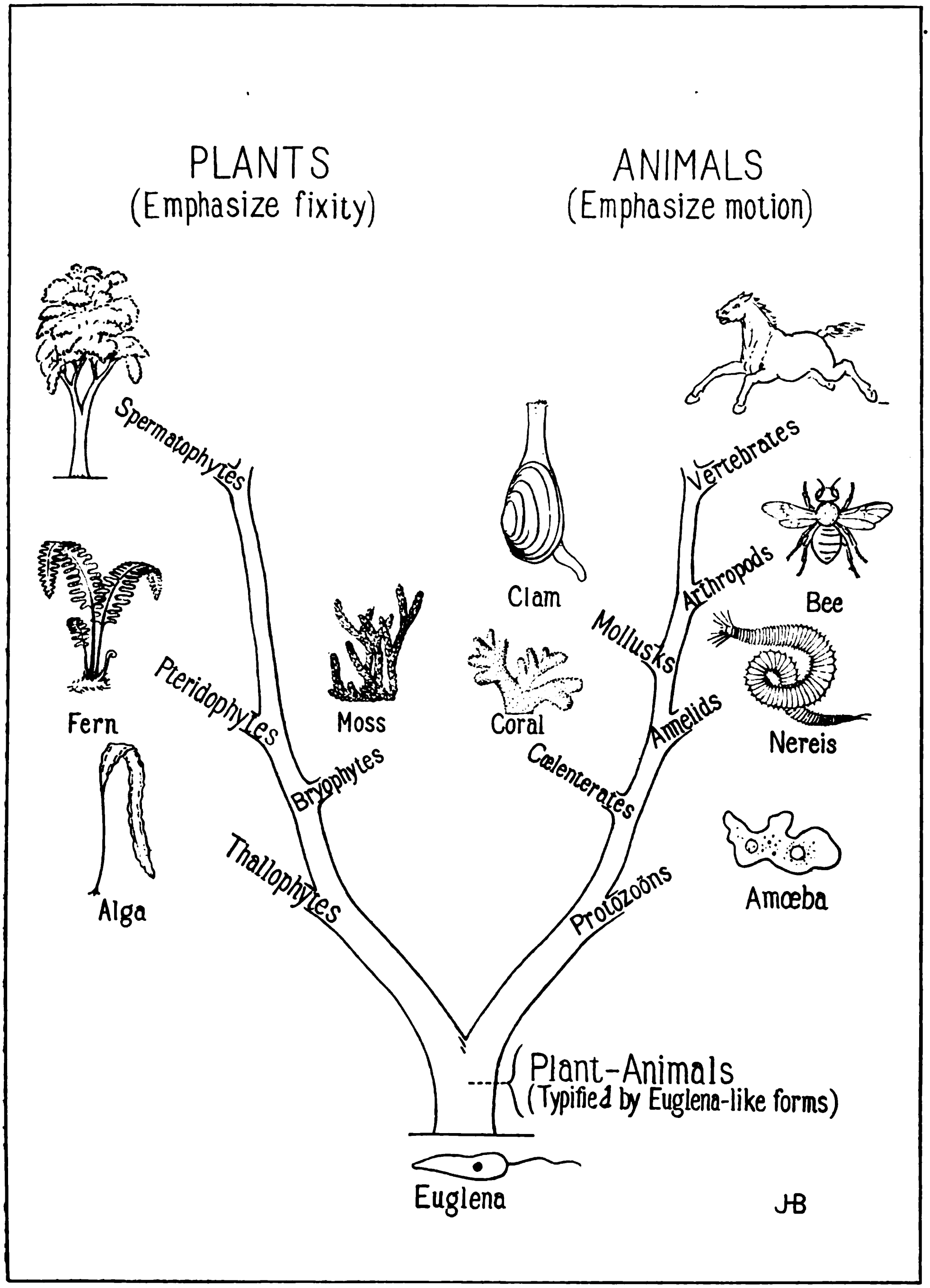


Diagram to illustrate the initial division of the life force into plants and animals and its repeated further branching into progressively higher and higher phyla. Only six of the twelve phyla of animals are represented.

tached to the earth and developed hard parts (cellulose or woody fiber) for the protection of the soft protoplasm, as a result of which protection, stimuli from the external world could penetrate with great difficulty. Owing to this lack of stimuli plants remain very low in consciousness (self-consciousness not meant). Animals, on the other hand, in choosing the more hazardous life of searching for manufactured food had to remain more or less free and as a result of this necessity for continued movement could not surround themselves completely with a hard skeleton. Consequently stimuli from the external world could penetrate with comparative ease and these stimuli have caused the development of a higher and ever higher consciousness with all its attendant nerves and body organs. All these divergent characteristics have followed as a natural consequence of the first choice.

H. W. S.

WHEAT CRISIS COMING

In his presidential address to the British Association at its meeting at Bristol in 1898, Sir William Crookes gave some valuable estimates of the world's supply of wheat, which, as he pointed out, is "the most sustaining food grain of the great Caucasian race." Founding upon these estimates, he made a forecast of the relations between the probable rates of increase of supply and demand, and concluded that "Should all the wheat-growing countries add to their (producing) area to the utmost capacity, on the most careful calculation the yield would only give us an addition of some 100,000,000 acres, supplying, at the average world yield of 12.7 bushels to the acre, 1,270,000,000 bushels, just enough to supply the increase of population among bread eaters till the year 1931." The president then added, "Thirty years is but a day in the life of a nation. Those present who may attend the meeting of the British Association thirty years hence will judge how far my forecasts are justified."

In his address before the Geographical Section of the Birmingham meeting of the British Association in September, 1913, Professor H. N. Dickson refers to Crookes' prophecy and says, after quoting a mass of statistics, "We gather, then, that the estimates formed in 1898 are in the main correct, and the wheat problem must become one of urgency at no distant date, although actual shortage of food is a long way off."

ENDLESS MAGNETIC CHANGE

In an essay on terrestrial magnetism John F. W. Herschel said:

"The configuration of our globe—the distribution of temperature in its interior, the tides and currents of the ocean, the general course of winds and the affections of climate—whatever slow changes may be induced in them by those revolutions which geology traces—yet remain for thousands of years appreciably constant. The monsoon, which favors or opposes the progress of the steamer along the Red Sea, is the same which wafted to and fro the ships of Solomon. Eternal snows occupy the same regions and whiten the same mountains, and springs well forth at the same elevated temperature, from the same sources, now, as in the earliest recorded history. But the magnetic state of our globe is one of swift and ceaseless change. A few years suffice to alter materially, and the lapse of half a century or a century, to obliterate and completely remodel the form and situation of those lines on its surface which geometers have supposed to be drawn in order to give a general and graphical view of the direction and intensity of the magnetic forces at any given epoch."

LOCATING BURIED NEEDLES

G. H. Monks, in the *Boston Medical and Surgical Journal*, describes an interesting method of locating needles buried in flesh tissues. The buried needle is magnetized by passing a magnet over the tissue where the needle is supposed to be located. Another needle, suspended from a fine silk thread, will have one of its poles attracted to the opposite pole of the buried needle, and its location may thus be determined with accuracy.

Science Conspectus

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The Aim of Science Conspectus

Not many years ago a man might say, " I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

VOL. V 1915 No. 4

NOTES FROM A VOLCANO LABORATORY

THE "PERSONAL DOCUMENTS" IN THE CASE OF KILAUEA AND MAUNA LOA, AND HOW THEY ARE TRANSLATING THE LAWS OF EARTH ERUPTIONS

BY T. A. JAGGAR, JR.

IN THE popular mind, an active volcano is supposed to be the most disorderly and haphazard thing imaginable. But when, at the suggestion of business men in Honolulu, the town of Hilo in 1912 subscribed the money to build an Hawaiian volcano observatory at Kilauea, there was evidenced a scientific spirit in the community far in advance of the popular conception. It became the function of the new observatory to study the two active volcanoes, Mauna Loa and Kilauea, from year to year as closely as possible with a view to finding out, apart from all prejudice, whether the gases and lavas come out, from the earth's interior in some orderly pulsations or otherwise. The gradual growth of the science of volcanology, from an historical history of disaster, has been well begun in Italy, Japan and elsewhere since the terrible catastrophe of St. Pierre in Martinique in 1902, and the foundation of the Hawaiian Observatory was a sound step in advance. It is my purpose to show here certain orderly results of three years watching and to urge the necessity of extending our facilities so that the summit crater of Mauna Loa will be more accessible.

In spite of hard times and hard prospects, the scientific work on the volcano has received encouragement from the community. The Hawaiian Volcano Research Association has been organized and anyone who is interested may join and receive the weekly bulletins which tell of the progress of the volcanic activities at Kilauea. We have members in Europe, United States, Central and South America and Japan. The Massachusetts Institute of Technology is a large subscriber and contracts to carry on the scientific work of the association. Co-workers have made important experimental studies here who have come from Italy, Switzerland, France, England and United States. We have taken part in the investigating of the great disaster of Sakurajima in Japan by sending an expedition hither. The leading business firms of these islands have subscribed to the scientific work being done here and the officers and directors of the Society have been leaders in the educational and commercial life of Honolulu; while Hilo took an important part in the initiation of the work, it is to be regretted that the Research Association has not more Hilo members and it is hoped that a substantial addition to the membership list will soon be made through the increased interest of persons living on the Island of Hawaii. For surely the inhabitants of this island have every reason to take an interest in the fires beneath their feet.

For three years the observatory at Kilauea Volcano, under the scientific direction of the Massachusetts Institute of Technology, has recorded the rise and fall of the lava in the pit of Halemaumau, has mapped the outline of the lava pool, has noted the nature of the activity and the temperature of some of the gas vents, while the seismograph pendulums in the basement of the Observatory have written, from second to second, a story of the local earthquakes and the tiltings and tremblings of the ground, and the meteorlogical instruments have made similar records of the rainfall, humidity, temperature and pressure of the air.

ROCK TIDES

It has long been known that the crust of our rocky globe rises and falls with a tide similar to that of the ocean. Like the latter, this slow creaking wave that passes through the rocks to a depth of many miles is occasioned by the pull of the sun and moon acting upon the revolving earth. The earth bulges somewhat in a zone around the equator and every month the moon moves north and south of the equator while the sun does so only every year. Each half year the sun reaches its farthest south or its farthest north, while the moon does so each half month. These great celestial swings make a squeeze upon the bulging crust of the equatorial belt over and above the normal tides which depend upon the daily rotation of the earth and the conjunction and opposition of sun and moon, popularly known as the times of new and full moon. There are other factors such as the times when the sun and moon are respectively nearest to the earth which modify the daily, semi-monthly and semi-annual squeezes which are crunching the rock crust on which we live, and a diagram showing all the complications of tidal theory and its effect at any point on the globe no one living is at present competent to construct. But from direct experiment, Professor Chamberlain, geologist, and Professor Michelson, physicist, of the University of Chicago, have recently proved a tidal movement in the solid earth, up and down, of about a foot twice each day and varying in amount through the lunar month and the solar year; and more than twice as great in a north-south direction as east-west. It is easy to understand how important such a movement is here in the equatorial belt of the globe where relatively small cracks going down forty or fifty miles are filled with liquid lava between walls of rock subjected to this rise and fall as well as to sidewise pressure, that is, to the passage of earth waves.

With knowledge of this ebb and flow in the rocky shell of the globe, we would expect careful measurements of the rise and fall of the lava column of Kilauea to show some kind of daily tides, some monthly change and a maximum every half year. Beyond this, in terms measured in years and centuries, there should be greater crises of some sort but in how far they should be tidal and how far dependent on the construction of the volcano is at present unknown. By construction of the volcano, I mean the building up of inner cones by lava overflow so as to confine the otherwise steadily rising lava column, as is the present case with Halemaumau, and complications of hot gas and congealing lava underground which may determine the relationships of Mauna Loa and Kilauea.

There is definitely a daily movement marked by a maximum and minimum of lava level in Halemaumau every few hours and there seems to be a tendency to marked rising about noon and midnight, the times of maximum barometric pressure. There is also a pulsating movement which I once recorded for twenty-two hours (in January, 1913) making a measurement once an hour of the height of the lava surface. The lava as a whole was rising, but the record showed a succession of quick jumps followed by slow sinking for three or four hours, each jump happening within the course of an hour and rising to a point slightly above that of the last previous jump. This jumping movement was probably occasioned by gas accumulation and release, while the net rise in the course of a day may have been tidal. It is to be hoped that some

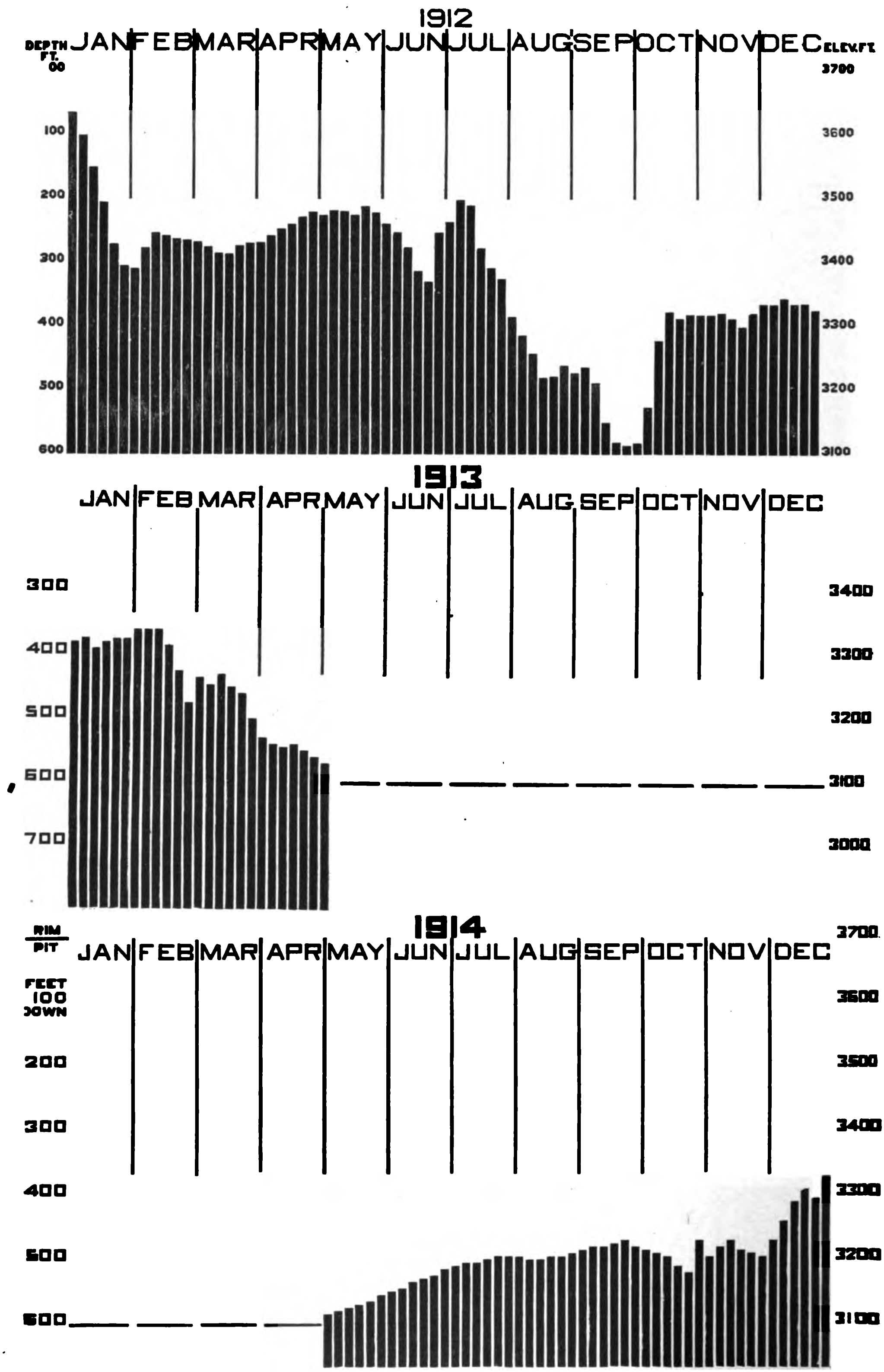
Hawaiian Volcano Observatory from the northeast

day we shall have the means during a time of high activity of Kilauea to keep a staff of assistants at work with a transit on the edge of the pit every fifteen minutes throughout a lunar month, and thus construct a diagram showing the details of tidal movement. This would necessarily be more expensive work than is now possible.

Diagrams have been prepared to show for the years 1912, 1913 and 1914 the rise and fall of the surface of the liquid lava measured from the edge of the pit Halemaumau, which is at an elevation of 3,700 feet above sea level. The average height of the lava for each five days has been shown as a black vertical line drawn with reference to a scale of depths below the rim of the pit indicated on the side of each diagram so that the tops of the black lines fluctuate in height in accordance with the measurements. From left to right across the diagrams are monthly divisions, each month of thirty days being represented by six of the vertical lines or columns, and the fluctuation in height to the top of the columns thus expresses for each month graphically the fluctuation of the lava.

These diagrams, beginning with January 1912, reveal on the whole a gradual sinking of the lava throughout that year and until May 1913, when the pit became so smoky and the lava sank so low, that for just one year no accurate measurement was possible. The year in question was from May 1913 to April 1914, when the lava was in general over six hundred feet below the rim of Halemaumau. From May of 1914 to the end of that year, the lava gradually rose but not so high as previously, and then from January 5, 1915, to the end of March 1915, it has gradually been sinking until it is more than five hundred feet below the rim of the pit.

Examining the details of these diagrams from month to month, it is easy to see that every month there is a distinct bend in the movement of the lava. The



Record of rise and fall of lava in Halemaumau

lunar month contains twenty-eight days and therefore does not check perfectly with the calendar month. Allowing for this, we find that there are thirteen crises in the year 1912 about a month apart, as follows: December–January high, January–February low, February high, March low, April–May high, June low, July high, August low, September high, September–October low, October high, November low, December high. The incomplete diagrams of 1913 and 1914 show similar features and it becomes clear from a study of these diagrams that there is a complete rise and fall of the lava column, a flow and ebb, every two lunar months. In general, rising takes place faster than falling, though this is not invariable.

We next come to a very marked characteristic of the movement of the Kilauea lava column; namely, the semi-annual high level. That this is connected with the change in declination of the sun north and south of the equator seems probable because both the changes in the sun's angle and the rise and fall of the lava are gradual and the quarterly culminations correspond. The 1912–1913 diagrams show high level (1911) November–January, low level February–April, high level May–July, low level August–October, high level November–January, low level February–April. The high levels are times of solstice, the low level times of equinox. This movement became so definite that it has been used during the past year for prediction, and the December rise of 1914 was expected. The prediction stated that there would be a fall in January 1915 and thereafter, and these things have come true.

There are thus short- and long-period movements of some regularity within a single year and these are gradually being verified by the accumulation of records for several years. The rising and falling of the Kilauea lava column is a sensitive index of the addition or subtraction of hot gases to a much larger mass of liquid deep in the earth and is also a sensitive measure of any compressing together or opening apart of the walls of the larger lava chamber underground to which the pool in Halemaumau is merely a small window. Geologists think that the lava comes from a potentially molten substratum at least fifty miles down and probably the passage leading down to this large mass of lava is nothing more than a crack or fissure. Kilauea has been built as a cone by the overflow of lava above this crack and this overflow has built up a central hole and radiating flows so that the lengthwise trend of the fissure beneath is entirely masked by the mechanism of a central pit above. Squeezing together the walls of a fissure containing liquid which opens into a small tube above will cause the liquid to rise and fall in the tube, and something of this sort takes place when a tidal squeeze warps out of shape the whole body of the earth, be it ever so slightly. As only three years of measurement have yielded such important results, we may expect that a half century of work at the Hawaiian Observatory will create a new science. The work must go on, it must unceasingly increase in accuracy of method and completeness of record, and it must be extended to other volcanoes around the Pacific Ocean for comparative results.

LONG-TERM ERUPTIONS

Even with the casual notes of travelers and scientific men made since the time of Vancouver's voyage in 1794, it is possible to glimpse something of the meaning of the relationship between Kilauea and Mauna Loa and of the long-term happenings at Kilauea which are marked by tremendous cataclysms. There have been two such catastrophes at Kilauea in historic times, the explosive eruption of 1790 and the tremendous earthquake of 1868. In both cases there was collapse of the bottom of Kilauea crater, and afterwards a new period of building up the bottom by means of lava overflows. We know nothing of what sympathy Mauna Loa may have shown with the 1790 explosion, but we know positively that Mauna Loa shared in every way in the earthquake and lava flows of 1868.

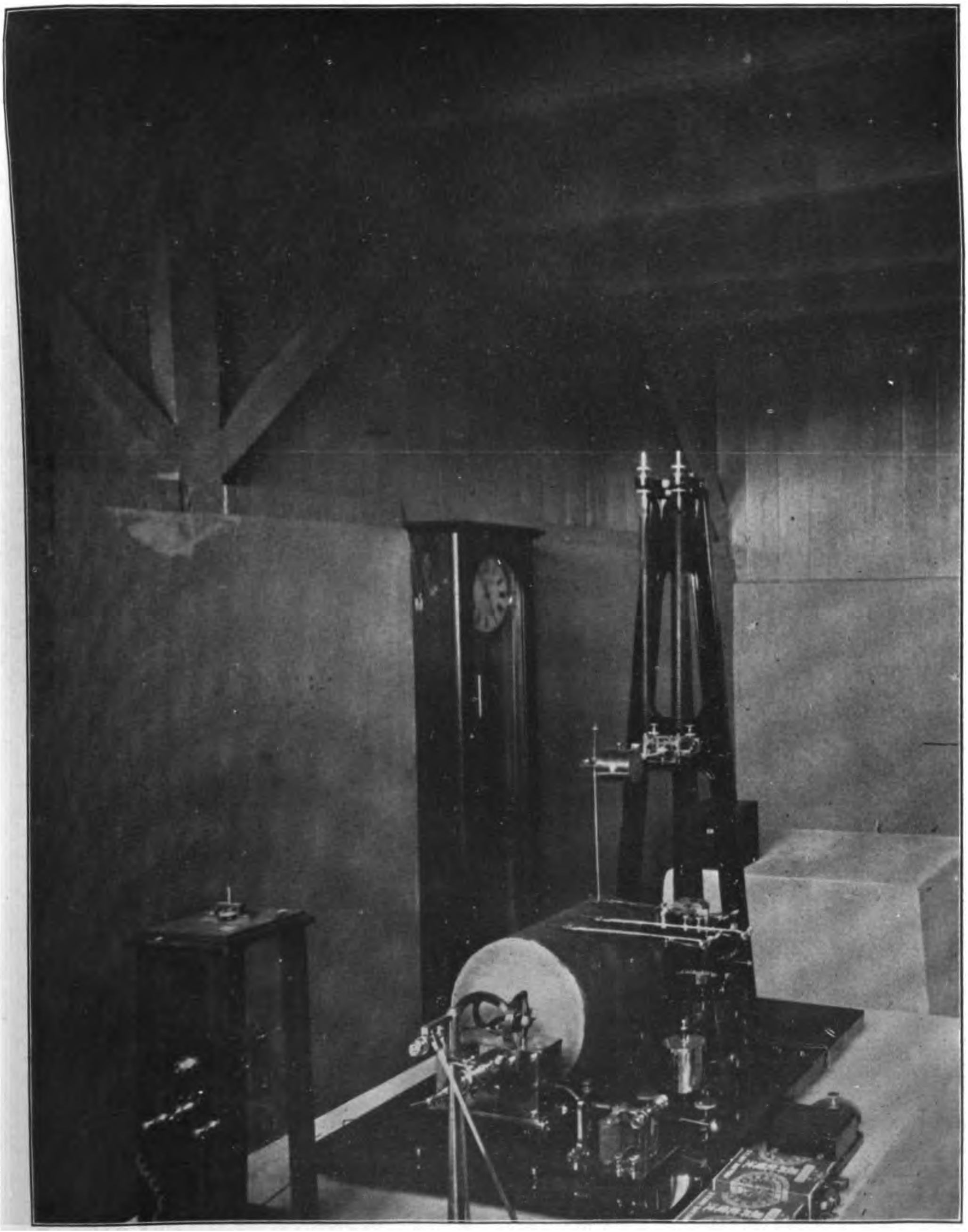
For Mauna Loa the 1868 crisis inaugurated lava flows at the south end of

Technology Station, Instrument Hut and A-frame, Halemaumau lava pit, Kilauea Volcano, north edge

the mountain and since that time the eruptions of Mauna Loa have happened about once in ten years with flows alternating north and south. The 1868 flow was south, that of 1880 north; the 1887 flow was south, that of 1899 north; the 1907 flow was south and accordingly the flow to be expected from the present eruption about ten years later, say 1917 or 1918, should come from the north.

The outbreaks of Mauna Loa every ten years or so, beginning with gas-lava fountains at the summit and ending with lava flows from the flanks of the mountain, seem to mean that some great force tends to steadily push gas and lava out of the mountain, while a restraining structure, the great slag heap of the mountain nearly 14,000 feet high, confines the lava within the oven so built up, and compels it to erupt in spasms—at intervals instead of continuously. There is some reason to think that all volcanoes have passed through stages from free-flowing continuous lava emission to greatly confined gas-lava explosion.

Kilauea Volcano is not so high as Mauna Loa, and after its evisceration in 1790, the lava, with many blowing cones and poolings within the crater, began to overflow and construct there a floor which was slowly built up into an inner cone; this cone-building by overflow being continuous throughout the nineteenth century until 1894 except for temporary interruptions by lateral outflow to the sea in 1823, 1840 and 1868 and possibly 1887. From 1894 to the present time, Kilauea has failed to overflow the inner Halemaumau cone and this period of twenty-one years, more than a fifth of a century, must be an important episode in the approach toward another great



Strong motion Seismograph Whitney Laboratory of Seismology

crisis like those of 1790 and 1868. Both Mauna Loa and Kilauea have shown diminution of volume of lava poured out from 1790 to the present time.

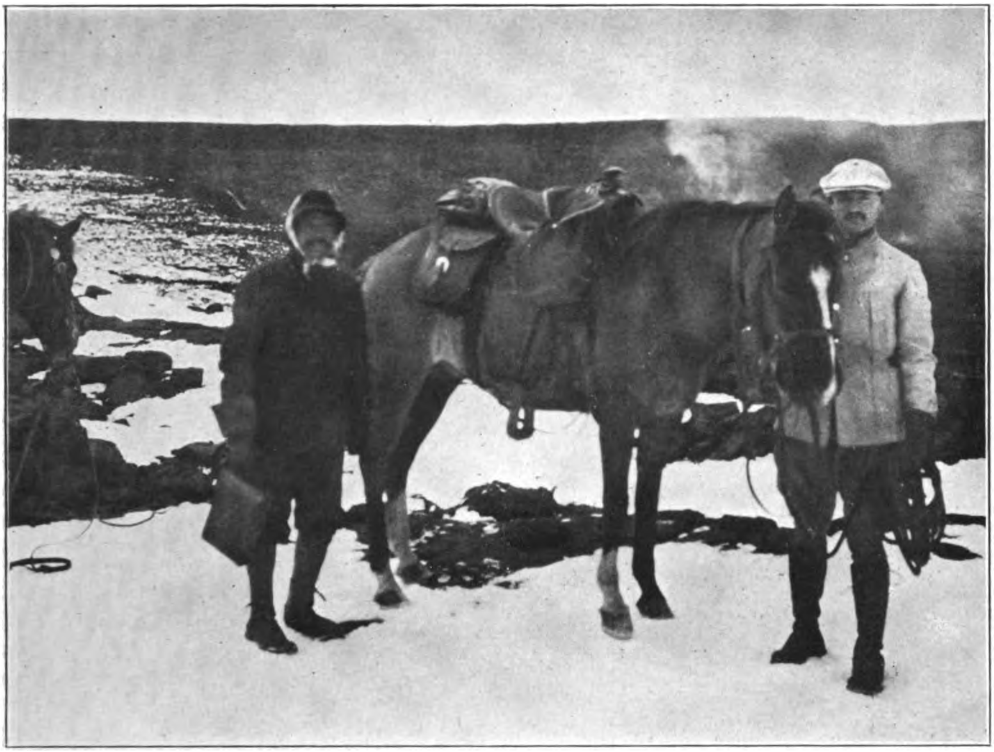
VOLCANIC SYNCHRONISM

It has frequently been asserted that there is no sympathy between the activities of Mauna Loa and Kilauea. This statement seems to me a loose one, unsubstantiated by facts. If there were a deep-seated connection somewhere between the surface of the earth and the substratum fifty miles down whereby both the Mauna Loa and Kilauea lava-gas columns come together, and the mechanism of the rising and falling columns is dependent on a squeezing earth crust and on hot gas which maintains a heat circulation in a liquid subject to rapid congealing, then we are not to look for any hydrostatic balance between the two columns. We have clearly to do with an uprising stream of liquid on each side of the system, that is in Mauna Loa and in Kilauea respectively which is restrained by its own tendency to solidify above when chilled, and is maintained by the release of hot gas and lava under pressure from below. If one of the two vents suddenly split open wider and so released to the air lava and gas under pressure, the other vent might be expected to be robbed of heat and of expanding gas and consequently to congeal and its lava to subside. It might well be that for a time, in the case of the sudden opening of one of the vents, the other vent would show a sympathetic kick or rise in the lava followed by subsidence as suggested above. The evidence of sympathy, therefore, in the behavior of the two vents would be complex and would depend on the sizes and heights of the orifices, the source and mechanism of the heat supply, the depth and size of the connection between them and the volume and pressure of the foaming body of lava available for the particular eruption in question. This last factor is doubtless dependent on the time interval which has elapsed since the last eruption, in the case of a volcano like Mauna Loa, if we suppose the succession of eruptions to be the spasms of a steadily accumulating fluid which tends to escape.

The records of the nineteenth century are too incomplete, especially as concerns the stagnant times at Kilauea, to give us any clear evidence as to whether Kilauea lava went down when Mauna Loa lava came up and vice versa, as might be expected from the above analysis. The record of the last thirty years, however, suggests such a relation.

After the Mauna Loa outflow of 1887, there was revival and vigorous activity of Kilauea culminating in 1894. During this time Mauna Loa was quiet. Kilauea lava subsided and disappeared after 1894 and Mauna Loa revived in 1896 and poured out lava from the Dewey Crater in 1899. Kilauea showed a little life but at a very low level in 1900 to 1902 and Mauna Loa remained quiet. Mauna Loa became active in 1903 with outflow in 1907 and Kilauea remained quiet. Kilauea revived rapidly after the Mauna Loa flow of 1907, rose to its highest level three years later in 1910, remained high for the three years 1910 to 1912, and sank slowly as shown by our diagrams from 1912 to 1914. During all this time Mauna Loa remained quiet. In 1914 Mauna Loa revived and at present, 1915, Kilauea is subsiding, to what end remains to be seen.

This sequence of events suggests a more or less periodic eruption of Mauna Loa about once in ten years and Kilauea activity during the repose periods of Mauna Loa. These ten-year periods are probably controlled by influences of lava accumulation and release rather than by any tidal strains. It may well be, however, that in the critical time of approach to the end of a repose period that an exceptional tidal stress in the crust of the earth will act as trigger to release an eruption. Other crises at still longer intervals in the history of these volcanoes are very likely always accompanied by sympathetic displays in both volcanoes, as in 1868 when the sympathy was unquestioned and in 1790 concerning which the accounts are very meager; we know nothing whatever of

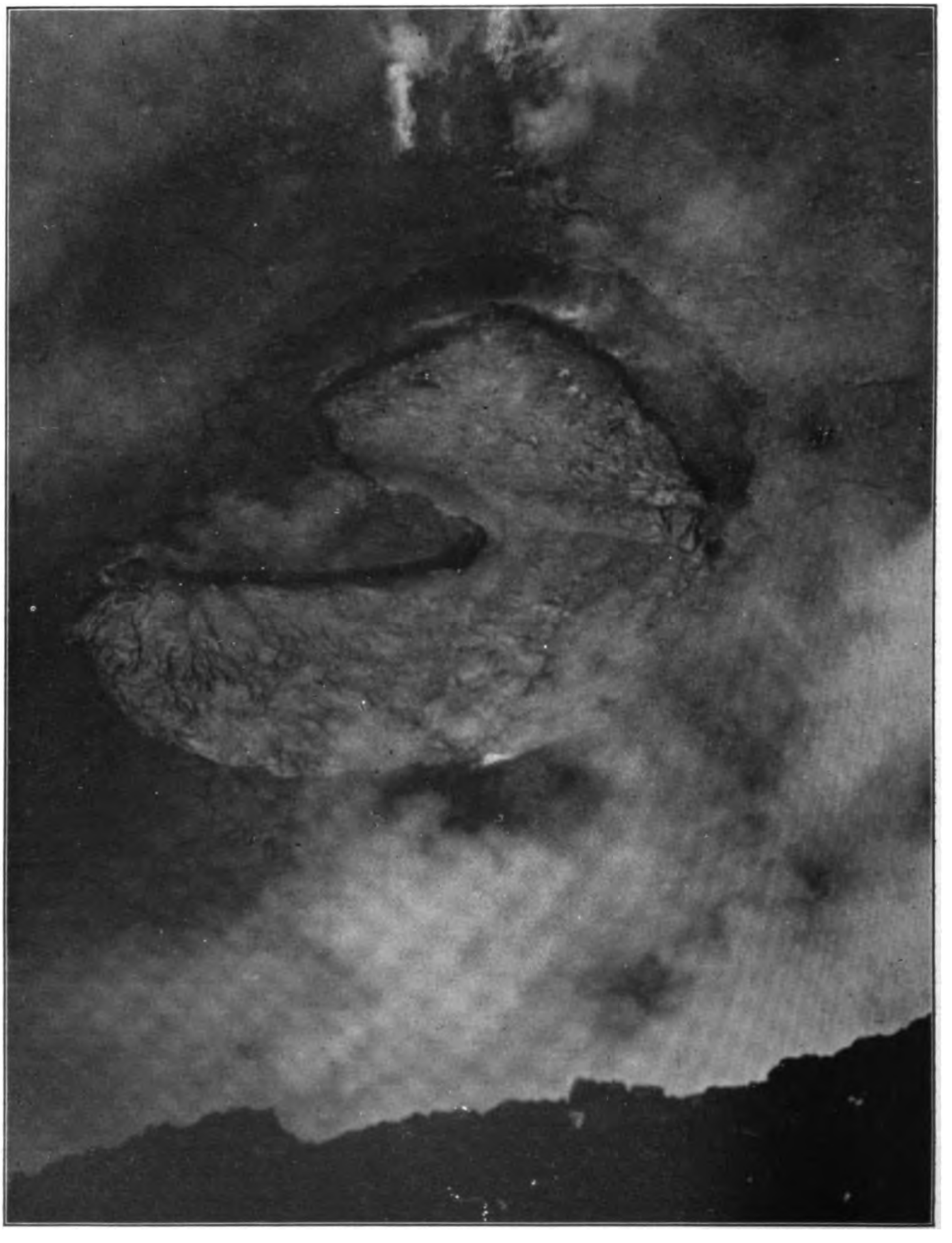


Alex Lancaster (left) and W. O. Wood (right) summit crater of Mauna Loa, December 15, 1914. Smoking lava fountains in the background. The Observatory Expedition

Mauna Loa or of the earthquakes and lava flows of that time.

CRITICAL STRESS DATES

Where there is accumulated stress underground from gas or lava pressure, it has been above suggested that the critical times of tidal squeeze, summer and winter, may act as trigger to release the gas or liquid and start an eruption. There are some dates when the earth squeeze is unusually strong, and these dates do not recur every year as they are dependent on coincidence of several variable relations of the sun, moon and earth. Thus either sun or moon may be at their nearest points to the earth, both may be farthest north or farthest south of the equator in their periodic swings, and they may be pulling together on opposite sides or on the same side of the earth. It is rare for all of these extreme positions to occur on the same day, but there was such an occurrence January 4, 1912, the time of the very highest rise of the Kilauea lava column shown in our diagrams. Also on the same day, the tide gauges in Hawaii showed the highest ocean tide ever recorded on them. The reason was that moon was farthest north and sun was farthest south, both were nearest to the earth and the moon was full; that is, it was pulling on the opposite side from the sun. Events of the year, of the half year and the month conspired on one day to make a rare event of combination which only happens at long intervals. It can be easily understood that such a day of unusual stress on our globe would press the button to start explosion or earthquake if volcano or straining earth crust were ready to be touched off.



Lake of molten lava, February, 1913, interior of lava pit, looking down from the east

TYPICAL VOLCANIC ERUPTION

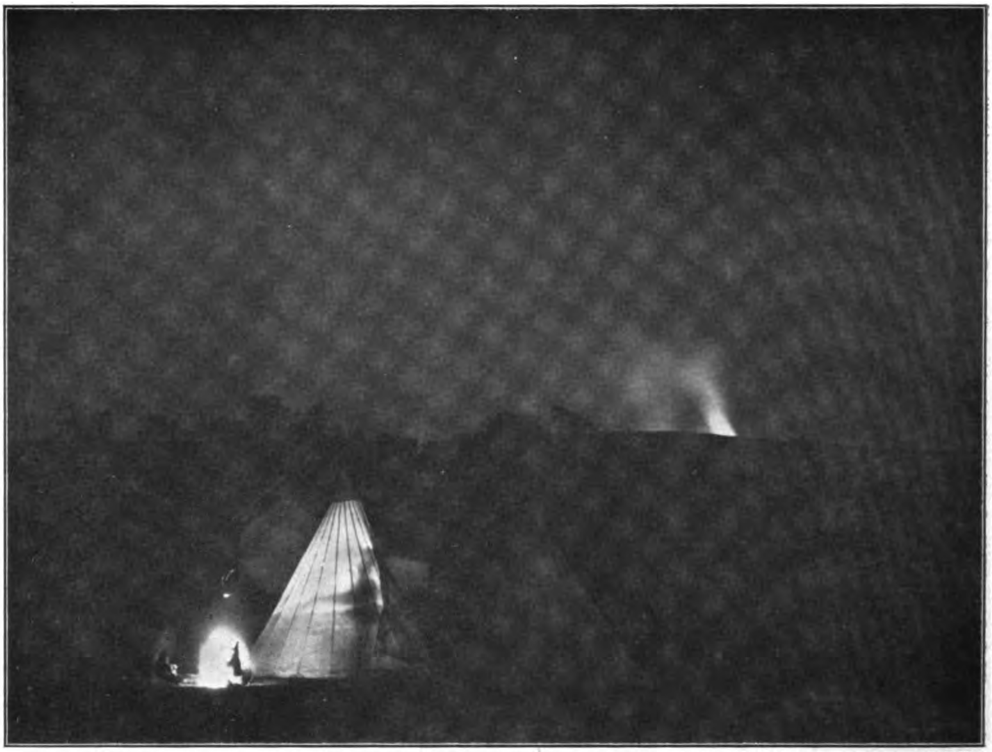
Science is still very ignorant about volcanoes and about the physical chemistry of hot lava filled with gas. Laboratory and field studies are working together, however, in demonstrating that the course of typical volcanic eruptions is everywhere the same in kind, differing only in degree; some volcanoes showing dominantly explosion and gas, while others are comparatively quiet with liquid lava as their chief product. Without discussing here the complex reasons for what happens, which would take us far afield, it is generally agreed that a typical eruption proceeds as follows:

(1) Unusual earthquake strain near the volcano for days, weeks or months with an abnormally large number of small earthquakes and some strong ones.

(2) A foamy lava rushes upward with a cracking open of the mountain through the central crater, the foaming being due to the gases contained in the fluid, very hot and very greatly compressed. According to the intensity of this gas pressure, the eruption may be a tremendous explosion which blows the lava foam to dust, or it may be a violent foam fountain with oxidation of the combustible gases making flames. The first case is that of Sakurajima or Vesuvius, the second that of Mauna Loa. The rise of the lava foam in any volcano follows upon a longer or shorter term of rest and in general, the longer the term the more explosive the outbreak. Like volcanoes are apt to have like terms of repose and the length of these quiet intervals appears to be one of the distinctive characters of a given volcano, though some volcanoes are much more regular than others. Given an average repose period drawing to a close for a particular volcano, and numerous earthquakes marking the underground stress, we can look for an eruption as most likely to come near the solstice, or on some date when the celestial tide strain is strongest.

(3) The adjustment of gas to liquid underground, a complex relation little understood at present, next takes place through the escape of large quantities of gas in the form of bubbles rising through the liquid, and if the upper part of the lava column is in any sense a froth, then this froth or foam may be conceived to sink or settle down as its bubbles burst. The gas itself, imagined to be contained in solution in the lava far down, passes from the dissolved to the bubble stage somewhere in the depths and thereabove expands and rises with dissociation and some chemical reaction which have various cooling and heating tendencies, the net result of which is volcanic eruption. Until these processes are imitated in the laboratory, science will know little about them, but the actual observation of volcanoes demonstrates without question that gas rushes forth for days or weeks after the first outbreak. This outrush may gradually decline, or it may be periodically renewed as though pulsating under alternate confinement and release. The term of gas escape before the liquid lava flows may be short or long, measured in hours or in years. There is no hard and fast line between explosive lava and liquid lava, and in a sense, the lava flows from the instant that a volcano begins exploding; the transitions between explosion clouds, foam fountains, frothy flow, lava flow and the rise of stiff lava plugs is represented in all gradations in different volcanoes and sometimes two or more of these processes are simultaneously at work in different parts of the same volcano.

(4) The liquid lava rises and escapes from the volcano in some form of lava flow and this stage is generally sharply marked as a term of days or months when the mobile melted rock is either welling up in the summit crator and higher, like a stiffening dome of very viscous slag, or the mountain rifts open along some ancient fissure and the liquid lava, perhaps spurting at first to the summit crater for a temporary display, finally makes a new crater lower down and pours a flood of melt for days or months down the flanks of the volcano in accordance with the habits of such volcanoes as Etna and Mauna Loa. The first type mentioned, with the stiff



Mauna Loa eruption from the northwest, November 27, 1914, third night of the eruption. Camp ground at Puu Lehua shows rapid decadence of the eruption

dome rising above the crater, is now known to be common in the West Indies, Aleutian Islands, Japan and elsewhere, but was unknown to geologists before the eruption of Mount Pelee in 1902. This escape of lava is the culminating achievement of volcanic eruption, that for which the eruptive process is devised in the economy of nature and hence brings the eruption to a close by relieving the strain due to accumulation. The gases have been allowed to expand, the froth and gas-charged liquid to escape and to cool.

(5) The cooling and congealing extends to a certain small depth below the crater and a term of repose ensues. Whatever the ultimate cause of the upward pushing force, be it gas pressure or the compressive stress of a shrinking globe, we know that the force is there. The lava has to escape once in so often, and the machinery of eruption adds so much new rock to the surface of the earth.

(6) A new term of accumulation in the deep region begins. There may be a few small earthquakes occasioned by the settling of the rocks over the void left by the lava flow, but in general, the years immediately following a complete eruption constitute a time of unusual quiet with little activity either seismic or volcanic. By complete eruption is meant the escape of the final lava flow for a given eruptive period, for some volcanoes have recurrent flows for several years before an eruption is finished.

MAUNA LOA 1914

Summarizing the six stages of a typical volcanic eruption, they may be briefly expressed as (1) earthquake stress, (2) gas foam explosion, (3) gas release, (4) liquid release, (5) solidification, and (6)

Inner pit made by subsidence of lava, January, 1915, within Halemaumau lava-pit, looking down from the north

new accumulation. Mauna Loa in 1914 illustrated the end of a period of accumulation (6), and a year of earthquake stress (1) initiating gas-lava foaming (2) in Mokuaweoweo, the summit crater, November 25, 1914, and gas release (3) took place through the summit orifices throughout December and January and probably continues at the present time (spring 1915) with subsidence for the time being of the lava froth.

That the approach to the solstice (December 22) and the earth's nearest approach to the sun (perihelion) about the same season induced effective stresses touching off the accumulated strain is probable. For in November, there were sixty local earthquakes, at the end of the month the summit fountains broke out and this activity endured until twenty days after the solstice, when the glow and fumes died away.

There remain yet to come in the present eruption of Mauna Loa stages 4, 5 and 6; namely, the escape of liquid lava, its solidification and the beginning of a new repose period. By this analysis, it should be plain that Mauna Loa is now active and must be so regarded until the lava flow comes.

It will now be profitable to review what the Hawaiian Volcano Observatory has done in preparing for and observing this eruption of Mauna Loa. The studies of men of science who have come to Hawaii from a distance, Dana, Friedlænder, Daly, Brun, Perret, Day and Shepherd, and the work of Brigham and Hitchcock, resident here, have thrown new light on sequences, intervals and the meaning of volcanic gases and these things are the basis of the deductions outlined in this lecture. Four of these workers have coöperated with the Observatory. The staff of the Observatory has made continuous records of the processes of Kilauea and has visited the summit crater of Mauna Loa at least once a year.

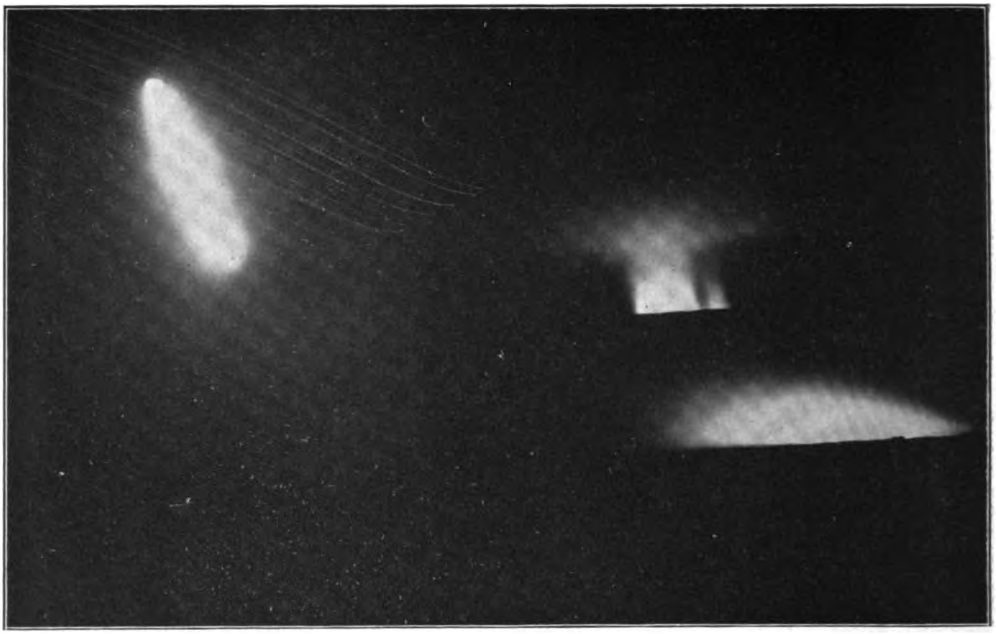
PREDICTION

From these records, I have worked out a tentative philosophy of the two volcanoes, as herein outlined, with a view to the practical service rendered the community in securing some basis of prediction, however inadequate and faulty our first attempts may be. Mr. H. O. Wood has been studying carefully the present day local earthquakes and the records of the terrific Hawaiian earthquake of 1868 and with me has been watching attentively the seismic and volcanic activities in their relation to the tidal and other stresses set up in the globe by the sun and moon. Mr. Wood has made a special study of the theoretical effects of the declination of the sun and moon north and south of the equator. From all these studies of records of the past, records of the present and of the processes of physics and astronomy, it became possible to foresee that Mauna Loa would have a summit outbreak between 1911 and 1915, that it was most likely to come near June or December, and this much has been verified in 1914. By similar reasoning, there remain the as yet unverified expectations (1) a very low level of the lava of Kilauea; (2) a lava flow from Mauna Loa, probably within four years and most probably in not less than three years; (3) the occurrence of a short-lived summit outbreak before the flow; (4) the time of this outbreak probably near June or December, this combination making January or July of 1918 likely times for the eruption to culminate; and lastly, (5) the lava flow should break out from a vent on the north side of the mountain, probably somewhere above the Dewey Crater of 1899. All this sounds like unwarrantably precise prediction, but the basis for it has been explained above. To such extent as such prediction proves useful and leads to proper preparation and precaution, it is justifiable.

In expectation of a coming eruption it was desirable for the Observatory to have a station on Mauna Loa occupied frequently for purposes of recording temperatures of fumaroles, local earthquakes, weather conditions and any other phenomena that might bear on the approaching outbreak. But it early became evident that this ideal could not be realized with the funds at the disposal of

The lava fountains of Mauna Loa from the east rim of summit crater, about one mile away. The main fountain, about 150 feet high, is under the white smoke, and appears against a dark half-dome of spatter of its own construction

the Research Association. Mauna Loa is a vast desert waste without water and rising to an immense height. Every expedition to the summit exhausts the energies of the men and animals employed, and the animals are frequently crippled and have their legs cut by the rough block lava. Consequently the ranchers will not rent good animals at any price and as there is no shelter on the summit, little water, no feed, violent winds and low temperatures, the men who can with difficulty be induced to go and act as guides or packers, object to remaining over night. The wages paid them and the hire of animals are high. All of this means that it costs several hundred dollars in order to take an unsatisfactory trip to the summit, see the crater, and return before any real scientific work can be done and even before the party is acclimated to the unusual altitude. In the winter time there is deep snow on the summit plateau and snow flurries or violent thunder storms with heavy gales of wind may occur at any season and make havoc in a camp of tents. There is no soil, so ordinary tent pegs cannot be used and there is no flat ground on which to sleep. There is no fuel of any sort and there are no hillocks or valleys to offer shelter. The crater Mokuaweoweo is surrounded by vertical precipices from three hundred to eight hundred feet high and the floor is accessible only by arduous climbing. The area of exploration for proper study of hot vents whence lava flows may issue, and of the seven or eight summit vents (pits and cones) including the great crater is fully twenty miles long by three wide, not including the separate area of flows in Kau to the



Kilauea, Mauna Loa and the Moon, November 25, 1914, midnight, first night of outbreak of Mauna Loa. From the east

Lava Whirlpool, interior of lava-pit, February, 1913, looking down from the east

south thirty miles away. It will be seen from this that Mauna Loa presents a problem of extensive exploration under difficult conditions and is not like Kilauea in possessing a single lava pit conveniently accessible.

The most that the Observatory has been able to do, therefore, in dealing with Mauna Loa during its repose, was to send an expedition to the summit once each year and to record the observations of other travelers whenever such were available. Observatory expeditions visited Mokuaweoweo in August 1912 and October 1913 and no unusual phenomena were noted, the only activity being very slight vaporing from cracks both in the bottom of Mokuaweoweo and in outlying fissures. These steaming fissures extend both northeast and south from the crater, the directions in which large rifts trend down the mountain along lines of historic lava vents.

COURSE OF PREMONITORY ERUPTION

In 1914 the Whitney Laboratory of Seismology in the basement of the Observatory, equipped with seismographs, registered groups of earthquakes from time to time in seismic spasms, and reports came from Kau and from the ranchers on Mauna Kea of sudden strong earthquakes in the line of the axis of Mauna Loa's greatest length. In November 1914 the registration of about sixty earthquakes in three weeks, the greatest number ever recorded in like time since the instruments were set up, greatly stimulated our attitude of expectancy. On November 25, 1914, about 12.45 p.m. the instruments showed prolonged earthquake movements of an unusual character, and at the same time cattle herders on Kapapala Ranch saw thick fume clouds puff up suddenly above the summit crater of Mauna Loa. After that the earthquake activity diminished.

The eruption became visible from the Observatory as darkness approached, November 25, and photographs were made of Mauna Loa from the vicinity that night and on succeeding days and nights. These photographs show the column of glowing fumes, the glow diminishing rapidly after the first night.

November 26 I started for the summit by way of Kona, being unable to get men or horses for the Kapapala trail in Kau. I reached the summit area in a blinding sleet storm November 28 and was unable to do any work on account of the storm. Fortunately two young men from Kau, Messrs. Forrest and Palmer, pushed their way to the summit on the previous night, November 27, and furnished the Observatory with a sketch map and notes. They saw ten or twelve fountains of lava along a north-south rift in the bottom of the crater, one of these in the southern part being between three hundred and four hundred feet high. December 2, Charles Ka was sent to the summit by the writer and saw only four fountains. Similar conditions were noted a few days later by Messrs. Baker and Bowdish and on December 15, an expedition from the Observatory reached the summit on the Kau side and saw only one large fountain about one hundred and fifty feet high and a few small ones. These were photographed, but conditions were too stormy to permit an extended stay on the summit.

Throughout December a watch was kept at the Observatory on the fume column over Mauna Loa. It was occasionally photographed and it persisted until January 10, 1915, showing a line of bluish fume by day and a dull glow over the mountain at night. After that date it disappeared, the fountains probably subsiding and the lava solidifying.

PREPARATION FOR FINAL CRISIS

The Observatory has a difficult and expensive task before it if it is to make adequate record of the spectacular closing stages of this eruptive period of Mauna Loa. We have learned a useful lesson of the futility of attempting a scientific siege of the crater fortress in winter-time without houses built in advance to shelter men and animals. Such houses ought to be built of stone both at the summit and on the north flank of the mountain near the probable site of the

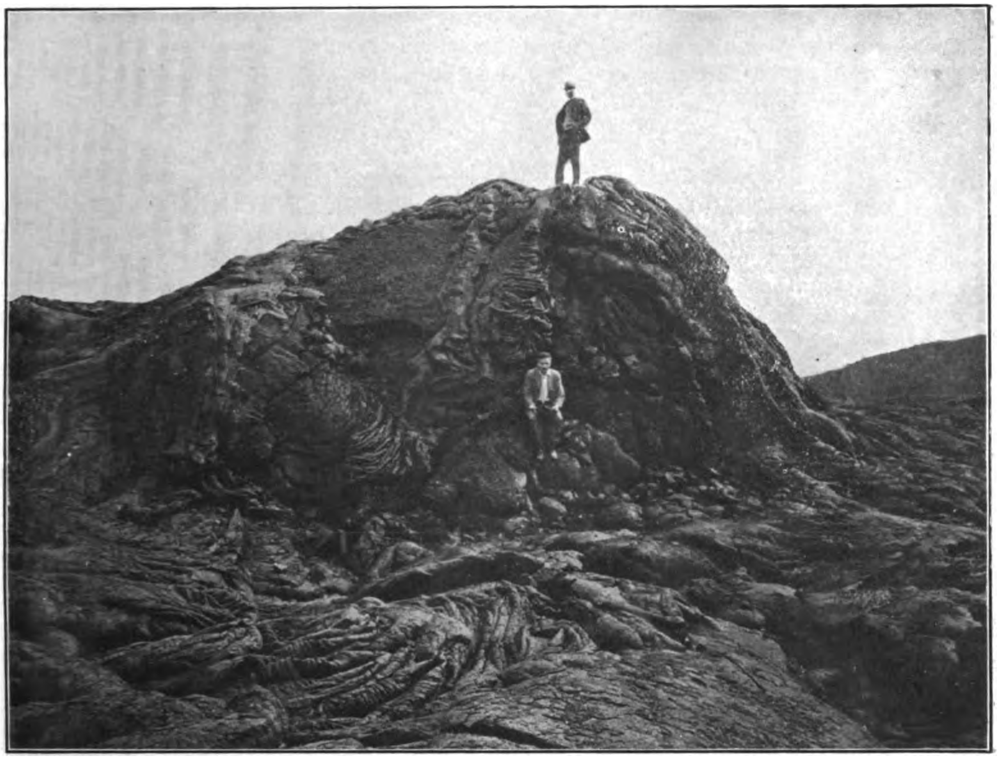
North walls of Mokuaweoweo, the summit crater of Mauna Loa, December 15, 1914

expected flow. The escape of the liquid lava after the months of temporary repose which we are now living through, will begin with more fountains at the summit; and with a slight earthquake prelude to warn us and a shelter camp, we ought to be able to have photographers ready to make pictures of the fountains at their highest. A probable time for this outbreak is about December, 1917, when the summit will be cold and snowy, but it may come sooner. It is certain that nothing can be done of scientific value at such a season without a summit hut and a shelter for horses.

The next stage will be a lava flow from a lower vent, probably six or eight miles to the northeast of the summit crater. A secondary camp should be prepared in this neighborhood so that photographs and measurements may be made of the fountains which generally shoot to an enormous height when the flow breaks forth, and thereafter of the flow itself in following its course or courses down the slopes.

These camps and the survey of trails to them will cost at least three thousand dollars and to maintain them and explore the field in their vicinity will cost three thousand dollars more. The work of survey and construction should be provided for at once, without delay, but there is no possibility of the Observatory doing this with its present means. It has no means to do anything beyond the recording of the activity of Kilauea and is barely able to do this owing to steadily decreasing income from subscriptions since 1912.

Governor Pinkham has gone on record as favoring legislative aid for this work, for the protection of the community and for the advance of science. Whether the money be furnished by the legislature, business corporations, an educational



Three-driblet dome; floor of Kelauea crater

institution, wealthy individuals, Honolulu, Hilo, or the County of Hawaii, or by all of these in concert makes no difference in the result, but it makes a very great difference if no one will furnish it. I suppose there is no question in anybody's mind but that the work ought to be done in accordance with the appeal of the directors of the Hawaiian Volcano Research Association approved by the governor and by the Honolulu Chamber of Commerce. It should not be a very heavy burden to raise two thousand dollars per annum for three years—1915, 1916 and 1917—and to turn this over to the Hawaiian Volcano Research Association with instructions to devote the money to systematic preparation for a survey of the expected lava flow from Mauna Loa.

The most that can be expected from the writer as director of the Observatory is a statement of why this should be done, what should be done and its probable cost. This he has attempted in this article. Mauna Loa has mobilized its forces and declared a war zone. The problem of furnishing the sinews of war cannot be left to the scientific staff.

INORGANIC FODDER

Germany has abundant supplies of potatoes, beet-roots and turnips, materials holding carbohydrates. Albuminous fodder, however, was scarce and had to be largely imported. An invention recently made in Berlin, says the *Scientific American*, provides a nourishing yeast containing more than 50 per eent. of albumen, prepared from sugar and ammonium sulphate. The sugar is bound to an inorganic base; in order to supply the albumen, the sugar is "fertilized" with ammonia, potash and magnesia, in the form of their salts, after which some yeast is introduced and a strong air current applied. The yeast then absorbs the sugar and the "fertilizer," thus resulting in the formation of a highly albuminous yeast.

THE PRINCIPLES OF HOSPITAL EFFICIENCY

A DISCUSSION OF THE ELEMENTS TO BE CONSIDERED IN GIVING THE HIGHEST EFFECTIVENESS TO THE MOST IMPORTANT OF OUR PUBLIC INSTITUTIONS

BY RICHARD WATERMAN

THE hospital of today occupies a very much broader field of work than did the hospital of a century ago. Its functions include not only the care of the sick, but also the prevention of disease, the scientific study of the causes and the treatment of disease, and the systematic education of doctors, nurses and the public. In order to perform these functions properly, the hospital has been obliged to erect an elaborate plant; to provide a great variety of expensive equipment; and to supplement the efforts of its unpaid scientific staff by employing a special staff of highly paid experts in both the scientific and the business departments.

A brief summary of the financial and operative statistics of the hospitals in the United States may serve to emphasize these statements. The *Modern Hospital* for September, 1913, says: "There are in the United States 6,665 institutions of record for the care of the sick, with a total capacity of more than 600,000 beds. By a modest estimate these huge figures represent a money investment in land, buildings and equipment of not less than $1,500,000,000, and an annual outlay for maintenance approaching $250,000,000.

"On the human side there are more than 100,000 trustees of hospitals and more than 65,000 physicians on hospital medical staffs. About 10,000,000 men and women contribute annually to the hospital funds and approximately 9,000,000 men, women and children are patients in the hospitals in the course of each year."

The fundamental idea in efficiency is the elimination of waste. A hospital is efficient if it thoroughly performs its functions—the care of the sick, the prevention of disease, the research work and the education of doctors, nurses and the public—with the least possible waste of labor, materials and money. There is an enormous amount of waste involved in the current methods of operating hospitals. The waste of money probably amounts to more than 20 per cent. of the $250,000,000 paid each year for current expenses; and there is in addition a waste of human labor and of opportunity that is incalculable.

We waste the time of our trustees when we fail to adopt a system of financial records and reports that will enable the superintendent of the hospital to present to the board at frequent intervals an intelligent statement of the work done and the unit cost of the work.

We waste the time of members of the medical staff when we fail to provide the facilities that will enable them to do their work properly. The most eminent specialists give their services to the hospital without charge; and when they are unable to do their work for lack of suitable equipment it is just as truly a waste of time and of opportunity as it would be if they were receiving a large professional fee.

We waste the time of our nurses when we require them to learn a dozen different ways of doing their work in the operating room or in the wards because we have not discovered the one best way of doing the work and adopted it as the standard method of procedure.

We waste a large amount of money when we provide for the construction and equipment of hospitals where they are not needed; and at the same time we throw away the opportunity to construct and equip new hospitals where they are needed.

We waste a large proportion of the first cost of construction and of the annual cost of maintenance of our hospitals when we fail to make ourselves familiar with the experience gained by others. For example, a large American city has recently completed the erection of a municipal hospital at a cost of nearly $6000 a bed. The best experts agree that this is twice as much as it should cost; and also that the arrangement of the buildings will make the annual cost of maintenance from 50 to 60 per cent. more than is necessary.

We waste a great deal of money when we buy useless equipment without investigation merely because it has been recommended by some prominent member of the staff; and when we duplicate expensive equipment many times over in neighboring hospitals and then allow it to lie idle the greater part of the time. No corporation that is organized for profit could afford to do this; nor can a hospital afford to do it.

We waste a considerable part of the money that is spent in the purchase of medical, surgical and household supplies. In every hospital about 60 per cent. of the cost of maintenance goes for supplies; and about 60 per cent. of these supplies could be bought to good advantage through a properly organized central purchasing bureau.

We waste at least half of the money that we spend to maintain beds for convalescent patients in a hospital for acute cases. It is well known that the per capita cost in a convalescent home is less than half the per capita cost in an acute hospital.

We waste a great deal of money by failing to devise and adopt a good system of serving food to the patients. In one large hospital that has a very high reputation, the food is handled seven times and reheated twice between the kitchen and the patient's bedside; and in one 24-bed ward the number of trays on which food is left untouched has been known to be as high as 33 per cent.

We waste a great deal of time and money in our dispensaries when we admit a large number of patients, who take a great deal of the time of the dispensary physicians for preliminary examinations at which a careful diagnosis of each case is made; and later when we fail to take the necessary steps to insure the return of these patients after their first visit. For example, one large dispensary shows in its report for 1914 that in a certain clinic 45 per cent. of the patients paid only one visit and adds that "not all of the work done for these patients was wasted, but most of it was."

We waste a large amount of money and human effort by failing to coördinate the various departments of the hospital; and by failing to establish recognized lines of authority so that we can direct the work of every person connected with the hospital along such lines that it will be of the greatest service.

An enterprise that spends $250,000,000 a year for current expenses is a large business undertaking and should be managed in accordance with sound business principles; and yet, it is true that very few trustees are prepared to apply the same principles in the management of a hospital that they apply, as a matter of course, in the management of their own business.

In these days of scientific management every progressive business man is studying the principles of efficiency. He knows that in his own business it pays to have a planning department that will help him to make sure that his staff is so organized, his buildings and equipment so arranged, and his financial and operative statistics so prepared that the work done will be as economical and as efficient as possible.

The business man should also realize that he can insure efficiency in the management of the hospital of which he is a trustee by precisely similar methods. A few hospital boards and hospital superintendents are already convinced on this point; but the great majority are still in doubt. This is largely due to the fact that there is at present no authoritative statement of the fundamental principles of hospital efficiency or of the general method of applying these principles.

In the absence of such a statement, it may be of service to present here a brief

outline of the principles of efficiency which are applicable in every field of human activity—business, professional, governmental, educational and philanthropic; and to show by a few concrete illustrations how these principles can be applied in the scientific departments of the hospital as well as in the business departments.

Mr. Harrington Emerson, one of the foremost efficiency engineers in the United States, has formulated the following list of the fundamental principles of efficiency: (1) Clearly defined ideals; (2) common sense; (3) competent counsel; (4) discipline; (5) the fair deal; (6) reliable, immediate and adequate records; (7) despatching; (8) standards and schedules; (9) standardized conditions; (10) standardized operations; (11) written standard practice instructions; and (12) efficiency reward. Each of these principles really is fundamental and should be given careful consideration by trustees who desire to make the management of their hospital efficient.

The ideals for which the hospital is working should be clearly defined. A few years ago the hospital confined its attention to the treatment and care of people who were already sick. Today, in addition to caring for the sick it devotes a great deal of attention to keeping people well. A few years ago the average hospital made no effort to follow discharged patients into their homes in order to measure the results of hospital treatment. Today in many of our best hospitals the follow-on system is an important part of the work. A few years ago, no systematic effort was made to add to the medical diagnosis and medical treatment a social diagnosis and systematic treatment by a trained social worker. Today, there are hospitals and dispensaries where the social worker is as much a part of the clinic as is the doctor or the nurse.

The hospital should use a reasonable amount of common sense. For example, it should avoid the unnecessary purchase of costly apparatus. At the present time it frequently happens that the expensive equipment needed to facilitate diagnosis and treatment is duplicated many times over by neighboring institutions. This results in extravagant expenditures and a great deal of preventable waste.

The hospital should seek expert advice when necessary. It is not possible for each of the 6,700 hospitals in this country to include as permanent members of its staff all of the specialists whose advice will be needed at one time or another. Each must, therefore, be prepared to employ competent counsel when needed—a hospital consultant to help in planning new buildings; an expert accountant to devise and install a system of financial records and reports; an efficiency engineer to discover and eliminate every form of preventable waste, etc.

The hospital should enforce discipline in all parts of its organization. Rules governing the treatment and care of the patients and the general conduct of the hospital should be clearly defined by the board of managers and placed in the hands of each member of the administrative, the medical and the nursing staff; and these rules should be enforced.

The hospital should give a fair deal to its patients and to the public as well as to its contributors, its managers and its staff of doctors and nurses. The fair deal requires that the interests of the patient treated in the hospital or in the dispensary shall be protected by making sure that in each case the physician or the surgeon in charge is really competent to do the professional work involved. The fair deal requires that the interests of the contributor who is asked to support the hospital shall be protected by giving him some assurance that the money he contributes will be used to good advantage. The fair deal requires that the interests of the doctor who contributes his services shall be protected by giving him as far as possible the facilities he needs in order to perform successfully his part of the hospital work.

The hospital should keep reliable, immediate, adequate and permanent records. The system of medical records should be such that it will aid the staff, not only in their treatment of the patients but also in preserving the history of each case in such a form that it will be available for use in the future as a record of ex-

perience and as an aid to teaching. The system of financial records and statistics should be such that it will enable the hospital executive to lay before the board of managers at frequent intervals a clear picture of the work done and the unit cost of this work; and will afford a common basis for the comparison of each hospital with every similar institution throughout the country.

The despatching of patients in a hospital should be just as prompt and systematic as the despatching of trains on a railroad. A patient who applies for admission to the hospital should be examined promptly by the admitting officer; assigned at once to the proper room or ward, and seen within a reasonable period by the visiting physician or surgeon on service; and instructions given by the visiting physician in regard to treatment and care should be carried out promptly and thoroughly by the resident members of the medical and nursing staff.

The hospital should establish definite standards by which to measure the economy and the efficiency of its work. One institution may have a per capita cost of $3.00 per day and another may boast of a per capita cost of $1.10 per day. It is necessary to establish some definite standard by which to measure the per capita cost before we can determine whether it is a credit or a disgrace to have a per capita cost of $1.10. One dispensary physician may treat twice as many patients in an afternoon as his colleague who is working under similar conditions. It will be necessary to know that he treats them with equal success before we can say that he is twice as efficient as his colleague.

The hospital should standardize the conditions under which its work is done, *i. e.*, it should make a scientific study of the results of experience in many hospitals in order to determine the conditions under which each class of patients can be cared for with the highest degree of success; and should then provide in each department the facilities indicated by the results of this study. For example, the principal service rooms should usually be located as close to the wards as possible. In one hospital these rooms are so close to the wards that the number of steps the nurses take in order to do their daily work is reduced to a minimum. In another hospital, the nurses are required to go to the other end of a long corridor every time they need to use the diet kitchen, the sink room or the duty room.

The hospital should standardize its plan of operation. A few years ago in one of the leading hospitals of this country, which has been used as a model by many other institutions, there were 33 members of the staff who had authority to admit patients. In the same institution today there are only two members of the staff who have this authority—an admitting officer and his assistant. In some hospitals the medical records for each service and for each dispensary clinic are kept in a different place and are not cross-indexed. In a few of the more modern institutions the hospital, dispensary and social service records are all consolidated, and it is possible to find in one place a continuous medical history of each patient from the time that he was first admitted to any department of the hospital.

The hospital should define clearly the rules and regulations governing the ordinary procedure for every department so that even when there are frequent changes in the personnel of the medical staff, the nursing staff or the administrative staff, the policy and the practice of the hospital will be continuous.

The hospital should give a suitable reward for efficiency in every department of its work. In the business departments, for example, the amount of compensation paid to employees should be determined by applying the same standards that would be applied in any well-managed commercial enterprise. In the scientific departments the professional recognition given to a member of the staff should be, as far as possible, directly proportional to his professional success. In many hospitals this principle is not recognized and promotion is made to depend not on efficiency, but on seniority of service.

Many different plans have been proposed with a view to increasing the effi-

ciency of hospitals in the United States—either individually or collectively. The American Medical Association has established a hospital section and has appointed a Committee on the Standardization of Hospitals. The Clinical Congress of Surgeons of America has appointed a similar committee, which submitted a report in November, 1913, making certain definite recommendations. The American Hospital Association has urged for years that a comprehensive study be made and that plans be developed for the classification and standardization of all of the hospitals in the United States; and at each of its annual meetings has appointed standing and special committees to report on various phases of hospital efficiency. All three of these organizations have urged the Carnegie Foundation to prepare a report on the classification and standardization of hospitals—a report that would perform as great a service for the hospitals of this country as the report on "Medical Education in the United States" has already performed for the medical schools.

The committees of these various organizations are now trying to formulate a satisfactory plan for accomplishing the purpose for which they were appointed. They realize that they must propose a plan that will not be objectionable to the hospitals; and one that it would be possible for some properly constituted agency to carry out, provided it is willing to undertake the work and assume the necessary expense.

It is not possible to make an individual study of each of the 6,700 hospitals in the United States and present the results in comparative tables. It is not possible to grade the hospitals saying—"this hospital is in Class A" and "that hospital is in Class B" nor is it desirable to do so. It is not possible to set up an arbitrary standard which every hospital must attain if it is to be regarded as a reputable institution. And yet these are some of the suggestions that have been urged as essential parts of any proposal looking towards the classification and standardization of hospitals.

It is possible to define the terms "classification" and "standardization" in such a way that under the definition both the classification and the standardization of hospitals in the United States can be accomplished, if sufficient resources are provided for the purpose.

For example, the American Hospital Association or the Carnegie Foundation or some other properly constituted authority might undertake—

(a) To prepare a schedule for the classification of hospitals providing for a number of different groups, each of which would include those institutions which are sufficiently similar to be comparable.

(b) To make a study of a few typical institutions in each group included in the proposed classification, and in addition of all of the teaching hospitals in the country; but to make no attempt to grade each hospital or to measure its efficiency as compared with other institutions.

(c) To define standards by which to measure efficiency in each of the proposed groups so as to make it possible for the managers of any hospital to apply the standards themselves and to measure the efficiency of their own institution.

(d) To include in the report a study of the work done by hospitals for the education of doctors, nurses and the public.

The suggested plan makes provision for defining standards by which to measure the efficiency of a hospital—standards that will help the trustees of any hospital in the country to answer the following questions in regard to their own institution:

(a) Is the organization of our hospital efficient?

(b) Is the management scientific?

(c) Are the buildings so planned that the hospital can avoid preventable waste?

(d) Is the equipment such that it is possible for the hospital to do the best work?

(e) Does the hospital spend a sufficient amount of money each year to insure good work?

(f) Are the medical and financial records kept in a form that will enable the trustees to measure the amount and quality of the work done and the unit cost of the work?

(g) Do the social service and follow-on systems enable the medical staff to ascertain the end results of their work?

(h) Are the physicians and surgeons getting as good results as they should in the treatment of their patients?

(i) Does the hospital coöperate actively with the public authorities and with various private institutions and agencies to protect the health of the community?

The proposed study of hospitals should result in establishing, under the auspices of the American Hospital Association, a Central Hospital Bureau that—

(a) Will place within the reach of every hospital in the United States the latest information in regard to hospital organization, management, construction and equipment.

(b) Will make the necessary tests and establish standards of quality and price for the medical, surgical and household supplies ordinarily used in our hospitals; and will thus help every hospital—large or small—to save the money now wasted in purchasing supplies without a full knowledge of current market conditions. This would result in a very substantial saving since the present annual cost of the supplies used in American hospitals is about $150,000,000.

(c) Will help to develop a community program for hospital work with a view to preventing the unnecessary duplication of expensive equipment and the overlapping of work that have proved so wasteful under the present system.

(d) Acting in an advisory capacity will aid individual hospitals in their efforts to increase their own efficiency and to make the best use of the funds entrusted to their care.

The proposed Central Hospital Bureau, with its skilled organization, its complete hospital information, its modern systems of investigation and record, its staff of hospital consultants, expert accountants and auditors—all at the service of each hospital—will make it possible for the smallest institution to be conducted with the same precision and skill as the largest and for all of them to effect a great saving in their expenditure of time, money and human effort.

A report developed along the lines suggested would be of great service to the hospitals, the medical schools, the nursing profession and the public.

It would be of service to the hospitals because it would enable each institution to measure its own efficiency and would present constructive plans for increasing the efficiency of those institutions which do not measure up to the standard.

It would be of service to the medical schools since it would help them to develop more effectively that side of their work which must be done in a teaching hospital.

It would be of service to the nursing profession since it would define standards for the training schools for nurses and show them what is generally recognized as the proper course of study, the necessary equipment and the desirable facilities for a training school for nurses. This part of the report would have a very wide application since a majority of the hospitals in the country have training schools for nurses. Many of them are sending out each year large classes of young women who are allowed to become graduate nurses and to enjoy all of the privileges of the profession, without having received an adequate training for the work.

It would be of service to the public since it would make clear the necessity for including in the organization of every hospital some provision for protecting the interests of the patients. It is an acknowledged fact that some of the best medical work and some of the worst is done in hospitals, and it is very desirable that some steps should be taken to enable the public to determine which hospitals are entitled to their confidence.

The proposed schedule for the classification of hospitals would provide for a number of different groups. It is obviously unfair to compare a large general hospital in New York with a 30-bed hospital in some small interior town; or a contagious disease hospital with a hospital for incurables, or an insane hospital with a children's hospital; but it is quite possible to group these institutions in such a way that those which are grouped together can be compared.

The proposed study of hospitals should result in a report that will present the essential facts—

(a) In regard to the number of hospitals in the United States, the number of patients treated, the number of managers, doctors and nurses actively engaged in the work, the amount of money invested, the amount of money expended each year for maintenance and other data that can readily be obtained from recognized sources of information.

(b) In regard to each of the teaching hospitals in the United States showing what it does for the education of medical students, for the further education of members of the medical profession, and for the movement to add to the available knowledge of the causes, the prevention, the diagnosis and the treatment of disease.

(c) In regard to the educational work done by hospitals where nurses are taught in the training school for nurses, in various departments of the hospital, and in various dispensary clinics; and where the public is taught by hospital and dispensary physicians, by lecturers and teachers in the out-patient department, by social service workers and by the publication of suitable material in the form of annual reports, special publications, and articles in the periodical and daily press.

(d) In regard to a few typical hospitals in each group included in the proposed classification.

HOW THE TELEPHONE DIAPHRAGM WORKS

The Electrical Research Laboratory of the Massachusetts Institute of Technology has been engaged the past year on a number of technical researches, and a report of Professor Arthur E. Kennelly of Cambridge, chairman of the laboratory, to President Maclaurin, sets forth a number of these interesting investigations.

An important point here is the fact that Technology has an electrical laboratory, the efforts of which can be devoted to scientific research as distinguished from commercial work and it is further a sign of the times that business men see advantages in the support of such a laboratory and assure its support to the extent of twenty to twenty-five thousand dollars a year.

One of the subjects on which Professor Kennelly recently reported to President Maclaurin is the behavior of metallic discs such as are used in telephones. It was desired to establish what the mechanical movements of the parts of such a disc might be with a view to establishing standard formulas for them. A research undertaken by Dr. H. O. Taylor of Cambridge, relates to the analysis of sound waves and a number of devices were tried in the hope of recording the passage of the wave in air. The attempts were in vain so that it was decided to investigate quantitatively the behavior of the metal diaphragm. With the exception of a very limited area in the centre of such a diaphragm, the field had been practically untouched.

The apparatus is comparatively simple, a metal plate such as is in use in telephones, a round frame in which to clamp it tightly about the edge and a triangular mirror supported from a bridge. The immediate purpose was to measure the motion of the metal disc. The point of the mirror was applied directly to the place which it was desired to measure; the mirror took up the motion of the disc and by means of a beam of light reflected from the mirror the nature and amplitude of the movement could easily be determined.

The flexibility of the apparatus was such that the motion of any point in the diaphragm could be measured in direction and amplitude and for glass discs as well as metal, the movement being actuated by a range of sounds from an organ pipe which corresponded in pitches to the limits under which the telephone must work.

There exist already some fundamental formulas of Bessel lately set forth by Lord Rayleigh and the correspondence of actuality to hypothesis has been shown by the Technology experiments. It has further been shown that within the limits of the experimental conditions the vibration decreases regularly from centre to edge and the plate does not break up into sections such as those shown by the Chladni sand figures.

HARDENED OILS

A MEANS of permanently changing an oil into a solid fat has been sought after by the oil chemists with almost the same zeal that the quest of the philosopher's stone was pursued by the alchemists. Nor did the fact that the product is only doubled in value, instead of being increased sixteenfold or more, diminish their ardor.

The problem was one similar to the preparation of sugar $C_{12}H_{22}O_{11}$ from starch $C_{12}H_{20}O_{10}$ (2 mols), here involving the simple addition of a molecule of water; in the case of the oils it was even simpler—the addition of three molecules of hydrogen,* a mere trifle of a tenth of an ounce or a little more than a cubic foot to the pound, being sufficient.

The procedures followed, by reduction of "red oil" with hydriodic acid, by chlorination and subsequent reduction with zinc, by reduction with nascent hydrogen, by treatment with electricity in an atmosphere of hydrogen, were all either too expensive or gave indifferent yields.

In a memoir published in the *Annales de Chimie* in 1905, Sabatier and Senderens called attention to the fact that hydrogen could be added to unsaturated bodies by the use of certain finely divided metals, which so far as could be ascertained played no chemical part in the reaction—catalysts—as they are called. A temperature of 300° C., with or without pressure, was necessary and nickel, cobalt iron, and copper were the catalysts employed.

As carried out at the present time, the process consists in causing the oil to circulate through grids supporting the catalyst, usually nickel or palladium, at a temperature of about 180–250° C., and under a pressure of ninety pounds of hydrogen. The melting point of the fatty acids ("Titer" or "Titer Test") is raised, and the operation can be interrupted at any point to give a fat of the desired consistency. As a result any oil, cottonseed, linseed, whale or fish, garbage grease, whether ancient or recent, sweet or strong-smelling, can be transformed into soap or candle stock of any desired hardness. The process does even more than this, it changes the before-mentioned oils—an ancient fish oil for example—into edible fats: the product is bacteria-free and physiologically uninjurious. So successful has the process become, that it is proposed to limit by law the production of edible fats and oils from loathsome sources; for example, garbage grease, cadaver and by-product fats. While it might be easy to pass this law, its enforcement would be extremely difficult, as the recognition of the different fats and oils now is well-nigh impossible; the difficulty of recognizing them after having gone through this process would probably be unsurmountable.

Products obtained by this method can probably be recognized by the fact that they contain small quantities of the catalyst used—nickel for example.

The question has arisen as to the physiological effect of small doses of this metal; it has been found that foods cooked in nickel or nickel-plated ware contain more nickel than the hardened fats, and furthermore that 99.8 per cent. of the metal is rapidly excreted from the system.

They are employed as soap stock—a fish oil which it would have been utterly out of the question to use, on account of the odor and consistency of the product, now gives a soap which has a "finer, cleaner and whiter look than that made without it." The slight odor can be masked by perfume. A disadvantage of the use of these fats is that the soap is so hard that it lathers poorly.

They find wide use as edible fats.

It is claimed for them that they can be heated hotter (to 455° F.) without smoking than ordinary fat: this cooks the outside of the food more quickly and prevents the grease from soaking in. Consequently it is less greasy, more digestible, dry and crisp. Another advantage is that no

$$* \ \text{lard oil} \quad C_3H_5\begin{matrix} COO\,C_{17}H_{33} \\ COO\,C_{17}H_{33} \\ COO\,C_{17}H_{33} \end{matrix} + 3H_2 = C_3H_5\begin{matrix} COO\,C_{17}H_{35} \\ COO\,C_{17}H_{35} \\ COO\,C_{17}H_{35} \end{matrix} \quad \text{tallow}$$

odor is absorbed; fish, onions and potatoes can be cooked successively in the same fat. Another claim is that one fourth less is used of these fats than of butter; further that it is all fat, while butter contains 5 to 16 per cent. of water.

Finally hydrogenated vegetable oils seem to offer a satisfactory substitute for animal fats to those who object to the latter from prejudice or religious scruples.

A. H. GILL.

RECONSTRUCTED CREAM

BECAUSE of many unfortunate experiences the public is naturally prejudiced against any alterations of food products, yet in some cases, such as cream, the result is beneficial rather than detrimental. In some parts of the South there are no dairy farms, and the table would be without cream were it not for a process of reconstruction. Desiccated milk is mixed with water and with butter from which the salt has been carefully washed out. The mixture is now forced through a machine called a homogenizer. By this process the butter fat is put back into the milk and delicious cream is thus obtained which cannot be distinguished in taste from the natural product.

Ice-cream makers employ a similar method in order to provide against inequalities of demand. On hot evenings there is a rush toward the ice-cream parlors, and to meet the greatly increased consumption the dealers draw on a supply of heavy cream which they have kept in a frozen condition. This frozen cream is thawed out, mixed with a proper proportion of milk, and put through the homogenizer. The homogenized mixture makes a smoother ice-cream than the natural light cream because, when the latter is frozen, much larger ice crystals are formed, which can be felt with the tongue.

E. B. S.

INOCULATING TREES

THE *Chemiker Zeitung* of recent date describes a method of destroying plant and household pests and fungi. Mercury is the material employed. In enclosed places it is used in the form of a vapor, but when trees are infected by insects, auger holes are bored in the lower branches in an oblique direction passing through the pith of the tree. These holes are filled with mercury, after which they are made air-tight with tree-wax. From two to seven grams of mercury are required for inoculation. This treatment is said to be not only effective for the purpose intended, but in most cases apparently assists in the growth of the plant or tree. The influence of the treatment continues for a year or sometimes more.

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The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

VOL. V 1915 No. 5

NATIONAL PARKS IN THE CANADIAN CORDILLERA

PHYSICAL FEATURES AND SOME OF THE MANY ATTRACTIONS IN THE CANADIAN NATIONAL PLAYGROUNDS SITUATED IN THE WESTERN MOUNTAINS

BY JOHN A. ALLAN

THE Canadian national pleasure grounds are becoming better known and more attractive each year to the citizens of the fair Dominion, and also to travelers from the United States and from abroad. Parks and pleasure resorts attract many tourists. All human beings have a peculiar strong instinct which craves for recreation. The number of nature lovers, pleasure seekers who visit the mountainous playgrounds of Canada, is annually increasing.

The scenery which a country contains that can be made readily accessible to the traveling public, and the pleasure opportunities which can be offered to the tourist can be ranked as one of the important natural resources of that country.

Statistics for 1913 show that the value of tourist traffic holds fourth place with respect to the revenue from Canada's national resources. According to the Canadian Travel Association, the amount of money spent by tourists in Canada in 1913 amounted to $50,000,000. The annual revenueof Switzerland from tourist traffic is about $150,000,000.

Mr. J. B. Harkin, commissioner of Dominion parks, in his annual report for 1914 says: "The slogan which Canada's outstanding advantages in the way of natural scenic and other attractions justify using in regard to parks' development in Canada is 'See America's Best.'" The slogan which has been previously adopted on the continent is "See America First."

Canada set aside her first mountain reserve for the benefit and pleasure of the people in 1887. Today there are eight national playgrounds in the Canadian Cordillera between the Great Plains and the Pacific Ocean. Rocky Mountains Park, Yoho, Glacier and Revelstroke Parks are situated on the main line of the Canadian Pacific Railway; Jasper Park and Mt. Robson reserve are along the Grand Trunk Pacific Railway; Waterton Lakes Park lies south of the Crows Nest line; and Strathcona Park is situated towards the centre of Vancouver Island.

Three of these parks are in Alberta, the remaining five are in British Columbia.

Rocky Mountains, Yoho, Jasper, Mt. Robson and Waterton Lakes Parks lie within the Rocky Mountain system of the Cordillera; whereas Glacier Park is in the Selkirks and Revelstroke Park is along the edges of the Selkirk and Columbia ranges.

From a scenic point of view these parks are all different and yet all attractive in various respects. Each of these pleasure grounds will be briefly mentioned.

THE ROCKY MOUNTAINS PARK[1]

The Rocky Mountains Park of Canada is the largest and oldest of the Dominion national playgrounds. By an Act of Parliament in 1887 an area comprising 260 square miles was "reserved and set apart as a public park and pleasure ground for the benefit, advantage and enjoyment of the people of Canada." In 1902 this reservation was enlarged to include 4,900 square miles, but as this was found to be too large an area to preserve properly, the boundaries were reduced in 1911 to enclose 1,800 square miles, which is the present size of this world-known playground.

This reservation is situated about latitude 51 degrees, on the main line of the Canadian Pacific Railway west of Calgary. It lies entirely on the east slope of the Rocky Mountain system in the Province of Alberta and extends from the western edge of the plains westwards to the summit of the Rocky Mountains, which is also the continental watershed.

This park includes the entire drainage basin of the Bow River within the Rocky Mountains and has roughly the form of an isosceles triangle with the base running in a northeast and southwest direction. The Bow River may be taken as the perpendicular, as it enters at the apex and leaves the reservation about the centre of the base of this triangular area. The gateway to the park from the plains is also a natural portal to the mountains and is known as the Gap.

This reservation is commonly known as "Banff Park" since it includes the town of Banff, one of the best known and most popular mountain tourist resorts in North America.

Banff and Lake Louise, both well known resorts in the Canadian Rockies, are the only two distributing centres for tourists within this park.

The Rocky Mountains Park contains many features that would attract the general public, the nature lover, the artist or the scientist. It embraces the most rugged, picturesque and majestic part of the Canadian Rockies; many lakes with superb, artistic setting, the sulphur-hotsprings at Banff, and above all a museum of scenic beauty so extensive and so varied that it equals any in the world. The contrast of forested lower slopes, rock-barren, towering escarpments and pinnacles, capped with snow and ice, and lakes large and small nestling in a forest or in a rock face, offer variety and enchantment to the visitor. The scenery of this park never becomes old or monotonous, as there are still many new and unexplored and even unvisited valleys and notches. The topography of the park is rugged and distinctly Alpine in character. The lowest valleys reach down to 4,200 feet above sea-level, while the highest peak is 11,870 feet, seen in the Matterhorn of the Canadian Rockies—Mt. Assiniboine.

Physiographically there are three very distinct structural features to be observed within this park. The first of these is the sharp line of demarcation between the low, rounded ridge of the inner foothills, and the gray massive limestone mountains, void of vegetation and lightened by patches of snow manteling the upper slopes of the massifs. This break between these two physically different units is marked by an almost perpendicular escarpment, 2,500 to 3,000 feet high. So sharp is this break that it is possible to walk along the extreme eastern base of the Rocky Mountains. This feature is particularly noticeable between latitudes 49 and 52 degrees. This escarpment marks the front of an overthrust block which when the mountains were uplifted was thrust in places several miles over the plains to the east. At the base of the escarpment is exposed the overthrust fault which farther south is called the "Lewis Thrust." Within the eastern edge of the park along this fault the Cambrian beds are thrust over the lower Cretaceous formations.

The other two structural features of note within the park are to be found in the mountains themselves; two thirds of the eastern slope of the Rocky Mountains consist of a series of sharply defined ridges all parallel to one another which present a steep escarpment on their eastern face

[1] Published by permission of the Geological Survey Ottawa.

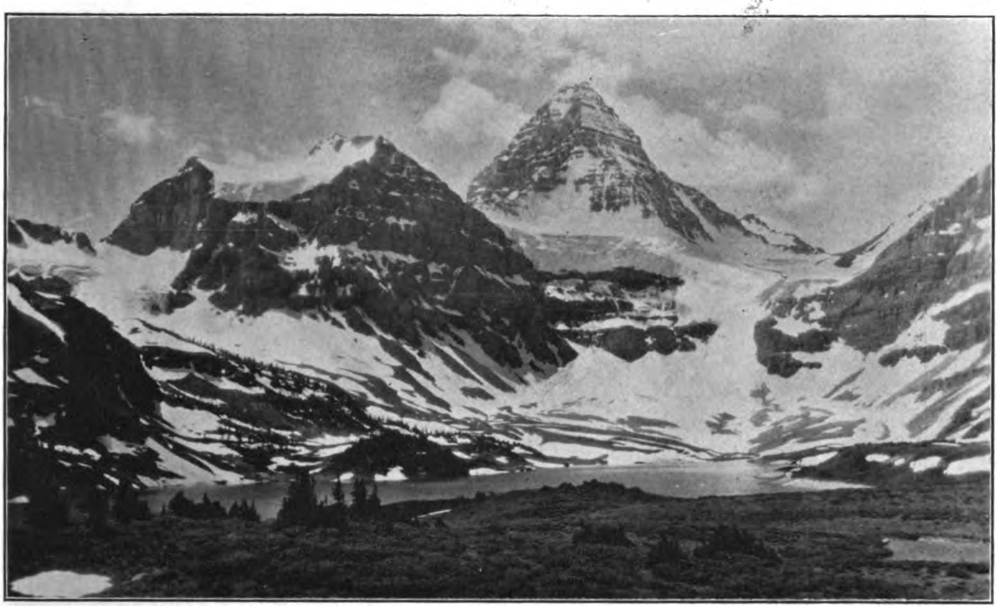


PLATE I. Mount Assiniboine (11,870 feet), the "Matterhorn of the Canadian Rockies," in the Rocky Mountains Park. Scenery typical of the range forming the continental watershed in the Canadian Rockies.

and a more gentle slope towards the west. These ridges are hugh uptilted fault blocks of rock, the more westerly blocks having been thrust partly over the block in front of it. The rocks in these fault blocks range essentially from Devonian to Cretaceous in age. The mountains in the western one third of the park are much older and belong to the pre-Cambrian and Cambrian periods. These formations have been up-arched into a broad fold which define the backbone of the Rocky Mountains system, as well as the continental watershed. The rocks in this portion are for the most part lying nearly horizontal. There is a sharp break which is represented by a fault between the younger formations on the east and the older formations on the west. The rocks within this park are entirely of sedimentary origin.

Rock structure has a marked influence on the scenery in the park. The types of forms to be seen about Banff, which is situated in the younger portion of the mountains, is quite different from that at Lake Louise which is situated in the older rocks.

Banff and Lake Louise (Laggan) although only 34 miles apart are very different as to location and scenery. The former is situated in the second range of the Rocky Mountains, on the floor of the Bow valley at an elevation of 4,542 feet above sea-level. Banff is the headquarters of the park with enclosures containing all varieties of mountain animals including several buffalo. It also contains a museum, meteorological station, headquarters of the Royal North West mounted police and the only food distributing centre for the entire park.

From a scenic point of view Banff is quite different from Lake Louise. It has a quiet, restful scenery developed in westerly tilted huge monoliths of rock with prominent escarpments on the east. No glaciers can be seen and the slopes are forested almost to the summits.

Lake Louise is situated at an altitude of 5,670 feet above sea-level and 533 feet above the railway at Laggan. The scenic features are truly Alpine consisting of a valley closed at one end by a glacier, surrounded by rugged mountains of flat-lying quartzites, limestones and shales,

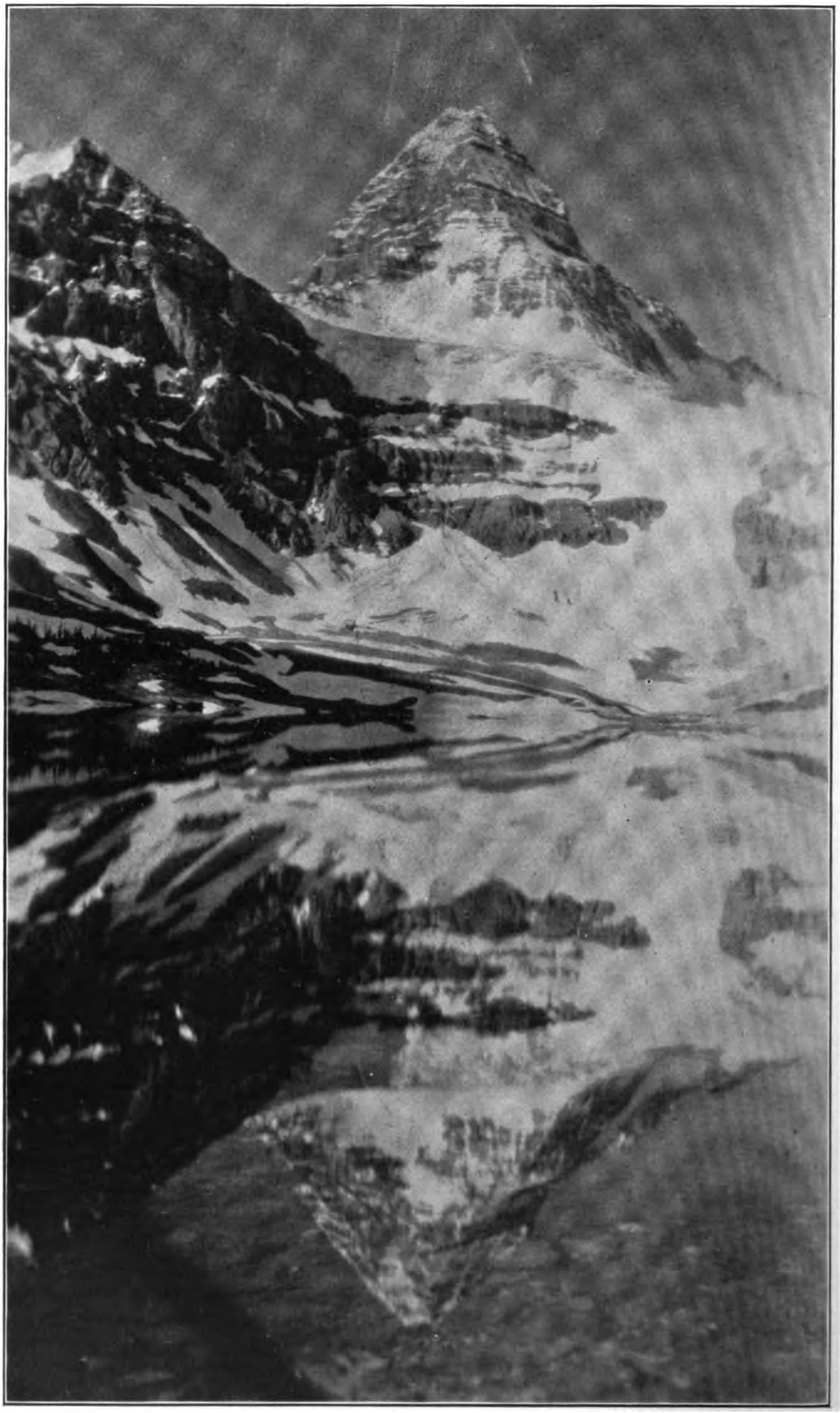


PLATE II. A perfect reflection of Mount Assiniboine in Lake Magog. Note the weird face-like form of some ferocious animal when viewed from the side.

whose summits average over 10,500 feet, and fringed with perpendicular cliffs or more gracefully curved slopes heavily timbered. The floor of the valley contains a lake of matchless beauty and the outlet of the valley hangs 600 feet above the floor of the Bow valley.

The highest and most prominent mountains are found on or close to the continental divide. The most lofty peaks include Mt. Assiniboine (11,870 feet); Mt. Temple (11,626); Mt. Hungabee (11,447); Mt. Victoria (11,355); Mt. Deltaform (11,225); Mt. Lefroy (11,220); Mt. Ball (10,825); Mt. Balfour (10,731); Mt. Fay (10,612); Mt. Aberdeen (10,340); Storm Mountain (10,309).

Among the many lakes of special individual scenic beauty that attract the tourist are Louise, Minnewanka, Vermilion, Bow, Hector, Spray, Shadow and Moraine Lake in the valley of the Ten Peaks.

This national playground can be visited easily and comfortably by all pleasure-seeking nature-lovers, whether in the railway coach, by carriage, by saddle pony or on foot. Within the limits of the park there are 300 miles of trails which are frequently traveled, and over 125 miles of carriage road. The government has taken steps to encourage trail travel by the erection of cabins at various points along certain trails. A telephone system is also being installed.

A motor road is being constructed from the plains to the coast. It is already completed through this park and crosses the continental divide at Vermillion Pass, fifteen miles west of Banff.

That the park is ever becoming more popular is witnessed by the yearly increase of guests shown in the hotel registers at Banff and Lake Louise. In 1914 over seventy-five thousand persons visited the park. Banff is also becoming a popular winter resort and offers facilities for all seasonable sports.

Year by year new places are being made more accessible to the tourist. The pleasure seekers will always find uncut pages in Nature's book to read. For magnitude, variety of scenery and accessibility, few places can surpass the Rocky Mountains Park.

YOHO PARK

Yoho Park, containing about 560 square miles, is situated on the western slope of the Rocky Mountains adjacent to the Rocky Mountains Park. The Kicking Horse River, rising on the continental watershed at the pass by the same name (locally called the Great Divide), divides the park almost through the centre. The grade of the upper part of the river is very steep; at one point, near the pass, in a distance of 2½ miles there is a difference in elevation of 900 feet. The Canadian Pacific Railway follows close to this river. In order to overcome this steep descent it has been necessary to construct two spiral tunnels. The upper tunnel is in the base of Cathedral Mountain and is 3,200 feet long, while the lower tunnel, in Mt. Ogden, on the opposite side of the valley, is 2,910 feet long. The grade on the railway is 2.2 per cent.

Field, situated at the base of Mt. Stephen, is the tourist headquarter for the park and is a famous resort, equally as well known as Laggan and Banff.

From a scenic point of view few districts can surpass that in and about the Yoho Park. The topography is distinctly mountainous and Alpine in character, sculptured to a considerable degree by glacial action, whereas the valleys have been broadened and deepened by the effect of valley glaciers. Kicking Horse valley is a typical example of a V-shaped glacial transverse trough with steep walls and a broad floor.

Yoho valley, the largest tributary from the north, shows distinct evidence of the handiwork of the glaciers. Takakkaw Falls, nearly 1,200 feet high and Twin Falls, about 500 feet high, entering the Yoho from either side, rank among the most superb in the continent. Both are formed in massive middle Cambrian limestones and both come from typical hanging valleys enclosing glaciers. The Yoho glacier closes the northern end of the valley. The many peaks in the President range on the west and the Wapituk range on the east, present a panorama truly majestic. This valley can be visited in comfort by carriage. Another popular drive from Field is to Emerald Lake, a

PLATE III. Mount Rundle at Banff, showing monoclinal structure with escarpment on the eastern face and gentle slope towards the west, typical of the eastern ranges of the Rocky Mountain system.

distance of seven miles along the famous snow-peak avenue. This drive passes the Natural Bridge where the water of the Kicking Horse River passes through a tunnel-like channel about four feet wide.

The park is well traversed by excellent trails along which the tourist is enabled to get a picturesque panorama for a radius of twenty-five to fifty miles.

Mention can only be made of such places of particular scenic interest to the tourist as the Ice River valley surrounded by such peaks as Mts. Goodsir (11,676), Vaux (10,881), and Chancellor (10,751): Ottertail valley; McArthur Pass and the Cataract valley with Lake McArthur, Lake O'Hara, Mt. Odaray (10,165), Cathedral Mountain (10,454), Mt. Biddle (10,876), Mts. Hungabee (11,447); Huber (11,041); Mt. Victoria (11,355), and many other peaks over 10,000 feet in the Bow range which forms the continental watershed. All of these mountains are readily accessible and can be climbed by the aspiring mountaineer. Mt. Stephen (10,485) one of the best known, can be easily climbed, and from its summit a magnificent panorama can be viewed. On the north slope of Mt. Stephen there is a small lead-zinc mine located 1,000 feet almost vertically above the railway.

Geologically this park is especially unique. Along the railway there is exposed one of the thickest Cambrian sections in the world. The total thickness of a continuous conformable series of quartzites, limestones and shales from the base to the top of the Cambrian was found to be over 18,500 feet.[1]

The rocks in the park are all sedimentary with the exception of a small area of igneous (plutonic) rock exposed in the Ice River valley. These rocks are alkaline in composition, ranging from nephelite and sodalite syenites, through ijolites and urtites to jacupirangites and other basic affinities. These rocks have been fully described by the writer in the memoir mentioned above. The mineral sodalite has a beautiful blue color and is much in demand by tourists as souvenirs.

GLACIER PARK

Glacier Park comprises an area of 468 square miles and is situated at the summit of the Selkirk range. This reservation is

[1]Allan, J. A., Geology of the Field Map Area — *Memoir* 55, Geological Survey of Canada, 1914.

PLATE IV. Looking up the broad valley of the Bow River at Laggan, showing Mount Hector (11,125 feet), on the right, Hector Lake in the center, and Mount Daly (10,332 feet), on the left. The shape of this valley indicates its glacial origin.

the most westerly of the three situated on the main line of the Canadian Pacific Railway. Rogers Pass, the summit of the Selkirks, is located about the centre of the park. Glacier is the only distributing point for tourists in this playground and is situated on the south slope of the broadly rounded glacier-marked Illecillewæt valley.

The scenery in Glacier Park is equally grand as that of the Yoho in the Rocky Mountains Park, but it is nevertheless quite distinct. The mountain peaks are more numerous and more pointed in form than those in the Rocky Mountain system. This difference of form can be accounted for geologically. The rocks are essentially pre-Cambrian in age and consist of schists, slates, gneisses and other metamorphic types badly contorted and broken. This portion of the Selkirks represents the old terrane from which much of the sediment was derived which gave rise to the great thickness of Cambrian and other Paleozoic formations in the Rocky Mountains.

Two physical features are of special note, and should be visited by all tourists; the Illecillewæt and Asulkan glaciers, and the Nakimu caves. Both are reached by good trails. Within a few minutes' walk from the railway it is possible to stand on the frontal lobe of a real living and moving glacier. This gives one an opportunity to study glacial phenomena in the process of change.

The Nakimu caves (caves of Cheops) are situated in a cirque-like basin towards the head of Cougar creek on the west side of the Illecillewæt valley. These caves can be readily reached by a good trail from Glacier House, a distance of about seven miles, and are wonderful in their formation. They consist of a series of irregular subterranean channels which have been formed by running water from a crystalline limestone. There have been several miles of these tunnels explored and they furnish an interesting and somewhat eerie expedition to the visitor. A description and map of these caves has been published by the Parks Branch, "The Nakimu Caves, Glacier Dominion Park, B. C.," Dominion Parks Branch, Department of Interior, Ottawa, 1914.

A considerable portion of the park still awaits the explorer and adventurer.

Game is abundant, especially the grizzly and black bear, whereas the more open mountain slopes offer a museum of floral variety for the botanist.

JASPER PARK

Jasper Park, although still quite young, is year by year becoming better known. This reservation is situated on the Athabaska River west of Edmonton and is reached by the Grand Trunk Pacific Railway. The park comprises an area of 1,000 square miles, which includes a strip 20 miles on each side of the railway and extending from the foothills, west to the continental watershed on either side of Yellowhead Pass which also marks the western boundary of Alberta.

The position of Jasper Park in relation to the Rocky Mountains is quite similar to that of the Rocky Mountains Park 200 miles to the south, in that they both occupy the entire eastern slope of the mountain system from the plains to the continental divide.

The topography in Jasper Park, although by no means so rugged and precipitous as that in higher altitudes to the south, is nevertheless attractive, pleasing and varied in its character. The valley of the Athabaska is broadly rounded and well forested. The broadened river course forming Jasper and Brulè Lakes and the meandering braided character of the stream in places add beauty to the landscape when backed up by a forested slope terminating in a massive grey limestone escarpment, with well-nigh perpendicular walls. Roche Miette is a good example of this.

The town of Jasper is the headquarters of the park and is also the most central point of distribution. It is situated on a broad flat terrace on the north side of the Athabaska at a point where the Miette River coming from Yellowhead Pass joins the Athabaska. From this centre an excellent panorama can be observed of the lofty ranges at the head waters of the Athabaska River, which contain some of the highest peaks in the Canadian Rockies.

The topography of the ranges west of Jasper is quite distinct from that to the east. A line crossing the railway about two miles east of Jasper and drawn in a northwest-southeast direction divides the younger portion of the Rocky Mountains consisting largely of westerly tilted monoclinal fault blocks of Devonian to Cretaceous rocks, from the older portion represented by Cambrian and older rocks that make up the ranges which mark the continental watershed. This structural feature is similar to that more fully described under the Rocky Mountains Park.

Pyramid Lake, about three miles from Jasper, offers excellent facilities for boating, fishing and camping.

Although outside of the present limits of the park, Maligne Lake, situated in the valley by the same name, is a most picturesque spot surrounded by the Opal and Maligne ranges. It is becoming a popular camping spot for visitors to the park and can be comfortably visited by a good trail from Jasper.

Another physical feature that is making the park well known is the presence of sulphurous hot springs (Miette hot springs) situated towards the eastern end of the park about seven miles from the railway in the valley of Fiddle creek. There are several of these springs and the temperature varies to a maximum of 127 degrees Fahrenheit. The water in some of these springs has been proved to have certain medicinal properties for rheumatics.

MOUNT ROBSON RESERVE

Mt. Robson Park reservation is under the control of the Province of British Columbia; it therefore is not a Dominion park. It will however be briefly mentioned here as a national pleasure-ground.

This reservation joins Jasper Park on the west and includes the ranges to the northwest of Yellowhead Pass, forming the continental watershed. This park is still comparatively young and has not yet been thoroughly explored. It however contains some of the most majestic and rugged scenery in the continent. Mt. Robson, "the Monarch of the Canadian Rockies," has an altitude of about 13,700 feet above sea-level. It is the most lofty peak in the Canadian Cordillera south of the Yukon. There are a number of other peaks in the Robson group equally

PLATE V. Mount Stephen (10,485 feet), with the town of Field in the foreground. (Yoho Park.)

as magnificent, but much lower in elevation. Associated with these summits are many square miles of glaciers and snowfields that add beauty to the panorama.

The Robson district is reached by a good trail from Mt. Robson station on the Grand Trunk Pacific Railway. Berg Lake and Lake Kinney are two beautiful large sheets of water at the base of Mt. Robson; they are connected by the Valley of a Thousand Falls. In the Fraser valley, along which the Grand Trunk Pacific and Canadian Northern Railways follow, Yellowhead Lake near the pass by the same name, and Moose Lake farther west offer facilities for boating and fishing; these also add charm to the surrounding scenery.

The rocks in this district are chiefly pre-Cambrian and Cambrian in age and are all of sedimentary origin.

A description of this district is given in the *Canadian Alpine Journal*, Volume IV, 1912.

WATERTON LAKES PARK

Previous to 1914, this was the smallest Dominion mountain reservation, having an area of 16 square miles. It has since been enlarged to include 432 square miles. This park is situated in the extreme southwestern corner of the Province of Alberta. It is bounded on the west by the continental watershed, on the east, for the most part, by the eastern face of the Rocky Mountains, on the north by Township Five and on the south by the International boundary line.

Waterton Lakes Park adjoins the United States Glacier National Park which has been described in *Bulletin* No. 600 of the United States Geological Survey.

Although this reservation has not yet become well known on account of the lack of roads and trails, yet it is bound to become a popular resort especially for the citizens in Southern Alberta. One of the principal features at present in the park is the chain of lakes after which the park has been named. The upper Waterton Lake extends for about three miles south of the International boundary.

This chain of lakes is walled in by steep promontories and rock escarpments which rise to an elevation of 8,000 feet. The lower lake lies just outside of the mountains and is separated from the middle and upper lake by a broad delta of alluvial material carried down by Blakiston

PLATE VI. Twin Falls, in Yoho Valley, Yoho Park.

Plate VII. Typical Yoho Park scenery. Mount Stephen on the right and Cathedral Mountain on the left, taken from Burgess Pass.

creek (Pass creek). The lakes within the mountains are entirely of glacial origin. There are other equally picturesque lakes within the park; of these Summit Lake (Oil Lake) lies in a large cirque close to the continental divide and extends across the boundary line into the United States. This lake is drained by Oil creek, so called because small quantities of crude petroleum have been obtained in three or four drill holes in this valley.

The scenery within the park is typical of the eastern part of the Rocky Mountains. The ridges making up the Lewis-Clark ranges usually have a steep escarpment on the eastern face and a more gentle slope to the west.

There are no true glaciers, but large patches of perennial snow may be seen on many of the higher slopes. Very little is yet known of the northern half of the park. There is a wagon road from the plains, up Blakiston (Pass) creek and over the continental watershed at South Kootenay Pass at an elevation of 7,100 feet. This road continues down the west slope of the Rocky Mountains into the Flathead valley.

Fish abound in the lakes and game of various kinds is to be found in almost any valley.

REVELSTROKE PARK

Revelstroke Park is the youngest and smallest of the Canadian Cordilleran playgrounds. It was set aside in June 1914 and consists of 48 square miles in the vicinity of the town of Revelstroke on the main line of the Canadian Pacific Railway. It is located on the extreme western flank of the Selkirk range on the eastern side of the Columbia River.

The park is being opened up rapidly by the construction of trails and a motor road to the top of Mt. Revelstroke. This peak is only 6,500 feet high, yet from its summit there is a magnificent panorama towards the Selkirks, the Gold ranges, the Cariboo district and up the Columbia valley. An endeavor is being made to make this park a popular winter resort.

PLATE VIII. Mount Robson (13,700 feet, the "Monarch of the Canadian Rockies"), and the gateway to the many glaciers and lakes in the Mount Robson reserve.

STRATHCONA PARK

In June, 1910, the government set aside an area comprising approximately 260 square miles to be used as a reservation and playground in the centre of Vancouver Island. This area was called Strathcona Park. Since the original limits of the park did not include much of the finest lake and mountain scenery, the government in 1913 extended the limits of this reservation to include about 800 square miles.

Strathcona Park is situated about the centre of Vancouver Island; the northern gateway is about 120 miles north of Victoria, seventy-five miles west of Nanaimo and twenty miles north of Alberni. The park can be reached from the south by way of the Nanaimo-Alberni Railway from Alberni, or from the north by way of Campbell River, which is reached by the island highway northwest of Nanaimo.

Although little is yet known of much of the park, each season is bringing it before the public, and showing that this reservation is worthy of being ranked as equally wonderful in the works of nature as other parks referred to above, which are situated far inland and in lofty mountain ranges.

The contrast is very sharp between lake and stream with their low shores fringed with magnificent and luxuriant foliage and the rugged mountain peaks, often snow-covered or mooring glaciers and snowfield, enclosing waterfalls and noisy cataracts, which resound for a score of miles.

The park is not without its lakes which afford ideal boating and fishing facilities. Buttles Lake affords a picturesque watercourse twenty-five miles long and one to two miles wide, winding down the centre of the park. Streams often with waterfalls enter on either side through heavily timbered shores which terminate in rugged rocky slopes often snow-clad and cold.

Campbell Lake consists of two basins, the lower being seven miles long and one and a half miles wide, while the upper one is about six miles long.

Numerous small lakes which, like the larger ones, are of glacial origin, add charm to the surroundings.

The topography on the whole is rugged

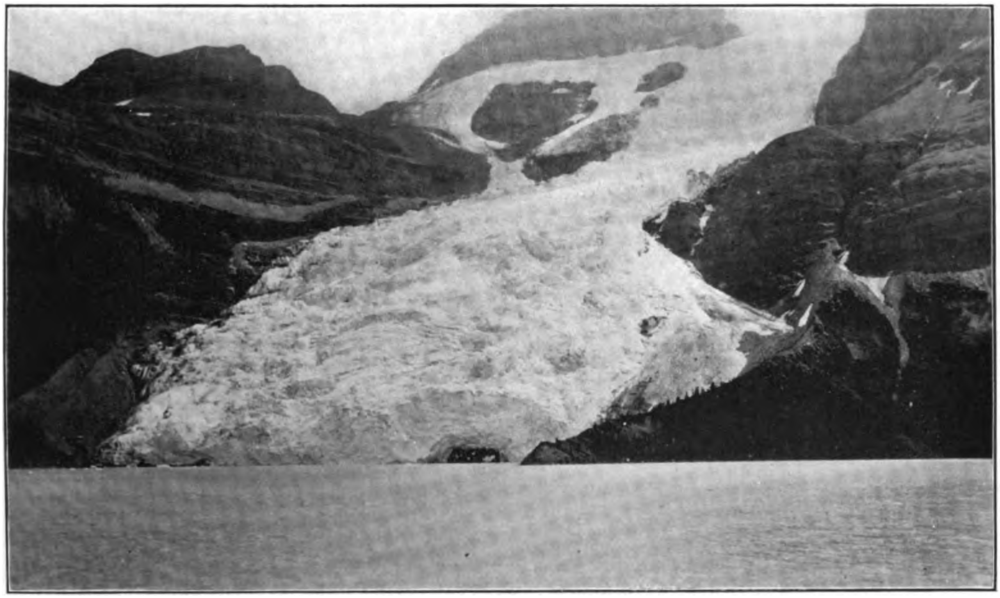


PLATE IX. Berg Lake and Robson Glacier, one of the many beauty spots in Mount Robson Park. Continuous movement in this glacier especially in the summer is evidenced by the cracking and groaning sounds which it makes. The white specks are icebergs which can be seen in the process of formation.

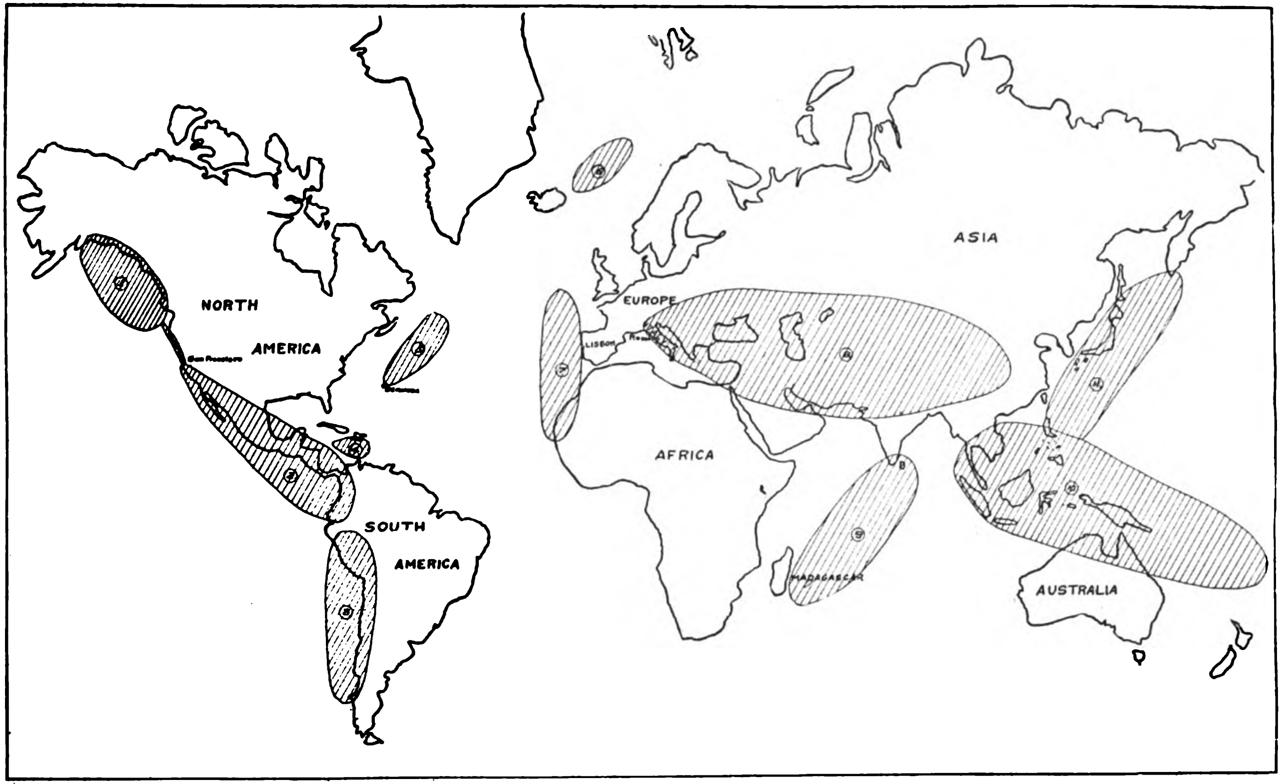
since the altitude ranges from sea-level to nearly 7,500 feet. Elkhorn peak, about 7,200 feet, is known as the Matterhorn of Strathcona Park.

The flora of the park has been studied by James M. Macoun of the Geological Survey of Canada. He reports having noted at least 350 species of phenogamous plants in the park which are very representative of the whole flora of British Columbia. Mr. Macoun writes "a week spent in Strathcona Park will give the botanist or plant-lover a better idea of the flora of British Columbia than can be obtained elsewhere in the same time." Writing about the coniferous trees of the park he remarks that the "Cedar, Douglas fir, pine and hemlock form as fine an example of Pacific coast primeval forest as can be found in British Columbia." Deciduous trees are rarely found within the park. Shrubs, ferns, berries, grasses, lilies, roses and many other flowering plants are numerous and varied, and offer broad fields of research for the botanist. Until the botany has been more thoroughly and extensively studied "any visitor to the park," writes Mr. Macoun, "may expect to find not only species that have not before been recorded from Vancouver Island but which are new to science."

ARTIFICIAL PATTERN LUMBER

A SUBSTITUTE for wood for pattern work, and other similar uses, may be made by mixing with hot water three parts by volume of starch, one part ground glue, two parts fine resinous sawdust. After the starch and glue has been dissolved by the water add the sawdust, and when the ingredients are thoroughly mixed, heat to 190°F., continuing the heat until the mixture becomes a hard mass. The resulting composition can be machined, sandpapered and varnished the same as wood. Besides offering most of the advantages of wood, it is practically fireproof, and is not affected by atmospheric moisture.

This material has no grain and when finished offers a much smoother surface than wood.



Map Showing the Areas of the Earth Chiefly Affected by Seismic Disturbances. It will be noted that within certain of these areas are the highest mountains of the world—which were uplifted during the most recent of the world's mountain making periods. Certain other areas are also marked by crustal warpings and such lack of equilibrium as to produce more or less frequent earthquakes.

1. Alaska-British Columbia belt. 2. California-Ecuador belt. 3. Peru-Patagonia belt. 4. West Indian area. 5. Bermuda area. 6. Iceland area. 7. North African-Portugal-Ireland area. 8. Alpine-Himalayan area. 9. South Indian-Madagascar region. 10. Malaysian area. 11. Japan-Philippine area. *Popular Science Monthly.*

TRUTH IN PUBLICITY

A CRITICISM OF CARELESS OR INACCURATE STATEMENTS IN PUBLIC HEALTH LITERATURE—HOW THE PUBLIC IS OFTEN MISLED BY INACCURATE PUBLICITY

BY CHARLES V. CHAPIN

THE modern world believes in education. The adult citizen as well as the child needs instruction. People are trusting less to legislation and more to education. Organizations as diverse as the New York Central railway and the American Social Hygiene Association are conducting campaigns of publicity. With this educational movement I am in hearty accord. It would appear almost an axiom that the teacher should teach the truth. Yet there are many to whom this does not seem to have occurred. If the tares of error are sown among the wheat they are sure to spring up and many a summer sun will come and go before they wither and die. Science is merely truth systemized. Though a distinguished sanitarian has told us that sanitary science should be tempered by common sense, it was spoken in jest. It is not real science but only the pseudo-science of the amateur which needs to be, not tempered, but thrown out root and branch.

In the past, many errors have been taught by alleged sanitarians and enthusiastic reformers of many kinds. Some of these errors are still intrenched in the minds of the public to plague us and hinder progress. Errors often did, and do, masquerade in the name of science, but they are not her offspring.

In the early days of public health work we copied the errors of our European teachers and added to them. There was little real science. Untested theory, or often pure fantasy, dictated sanitary procedure. Let us turn to the teachings of the seventies and eighties of the last century. The environment was then the field for sanitary effort, not the person. Out of about 800 pages of Parkes' Hygiene, only 27 are devoted to the contagious diseases proper. The soil was in those days thought to be a common source of disease. The foul emanations from the decomposing organic matter were sucked up from cellars by the warm air of the house and carried sickness and death; ergo, if one would live, make the cellars impervious with asphalt. One state official writes,

"There can be no doubt that the ground-air under the village of ——— is seriously contaminated with general filth and specific enteric poison, and that this is liable to pass into any or every house in the village, carrying the seeds of disease with it. The ground air is not only drawn into houses by heat, but with every rise of the sub-soil water it is forcibly expelled from the ground into the houses and the streets. This air comes loaded with polluted moisture and may be either the cause of typhoidal or malarial fevers, or of dysenteries, diarrhœas and consumption."

The supposed danger from cemeteries is well illustrated by answers to an inquiry for opinions sent out to sanitarians. one writes:

"If one thing in sanitary science is better settled than another it is that decomposing human bodies pollute both the air above the ground, the ground itself, and the water that percolates through the ground. Polluted air and poisoned water are certainly detrimental to public health."

Another says:

"I do regard the presence of a cemetery, either large or small, in a city, as

detrimental—yea, very dangerous—to the public health. I think poison enough may be derived from one human body to contaminate the well water and the air for a long distance under favorable circumstances for its diffusion. I should hesitate much to drink or use the water from a well situated one-half mile from a cemetery, if the intervening soil was gravelly or sandy, unless said water had recently been subjected to a searching chemical examination."

Filth, we were told, was the principal source of disease. In it bred hypothetical germs, or from it arose still more hypothetical gases. The pig pen, the garbage bucket, the trash pile, the manure heap and the privy vault were equally dangerous. How exasperating to us, who appreciate the evidence that only certain kinds of dirt are dangerous, is the persistent error that all dirt is dangerous. Belief in the supreme importance of dirt as a cause of disease persisted long and at the close of the Spanish war Colonel Waring was sent to clean the city of Havana and so exterminate yellow fever. He did clean it but the fever was more virulent than ever and only the real science of Reid and its brilliant application by Gorgas conquered this pest of our tropics. Even the less obtrusive forms of dirt were dangerous. Listen to what one writer says.

"A prominent physician reports the occurrence in the northern part of the state, of twenty-seven cases of severe typhoid fever, some of them fatal, the direct result of the unhealthy influences of a damp and uncleanly cellar."

"To prevent the emission of ground, air or soil moisture from the cellar bottom or sides, the sides must be laid in good hydraulic or asphaltic cement, and the bottom in the same, or in alternate layers of asphaltic cement and felt saturated with bitumen."

"Disease is also sometimes caused by half cleaned or neglected cupboards, closets, pantries, or provision rooms, where bits and crumbs are left to decay."

"It is not necessary, however, that contaminated water, or the effluvia of surface or pooled filth, or uncleanly cellars or pantries, should be sufficiently poisonous, to produce directly and obviously the common diseases of summer, to be sources of danger; for other derangements of the human economy, varying with the constitutional peculiarities of individuals, may be as easily induced by the same causes; and in absence of any or all acute diseases, it is quite probable that very many of the obscure ailments of numerous persons, not immediately dangerous, have the same origin, and are consequently so perpetuated; making the victim's life almost intolerable with aches and pains, and functional disturbances of the nervous system, the stomach, bowels, kidneys and other organs almost endless."

"The great, the indispensable remedy is cleanliness, and not only of inanimate but of animate bodies also, for filth is the same disease-producing agent, whether upon the surface of the earth, or in or about the habitations of man, or incrusted upon the surface of human bodies."

A dead human body was long considered a great menace. Dead from contagious disease it might cause an outbreak. This theory gave rise to burdensome restrictions as to transportation and funerals which no one, now that we have taken pains to study the subject, would ever think of enacting. The mind of the sanitarian was obsessed with the idea that dead things are more dangerous because of contagion than are the living, hence the fear of fomites and the worship of disinfection, though no one seems to have made even an effort to find out whether disinfection is really necessary.

Air was the chief vehicle of infection, nay, it was infection itself. The emanations from cellars and untidy cupboards which dealt death and destruction through the house have been referred to, as well as the more specific effluvia which gave rise to yellow fever, consumption and diphtheria. Conditions became even more terrible when evidence began to accumulate that living germs, not gases, were the cause of infectious diseases. Listen to what was taught in 1878 in my own state.

"These germs, by their exceeding light-

ness, may separate from any of the emanations from the body, either after having been thrown out upon the surface of the ground, and rising therefrom to be wafted away in the currents of the air, to infect some other person or persons, weeks or months afterwards, and the scores of miles away, or, separating immediately in the sick chamber from the breath, perspiration, scaling off, or other discharge from the body, may rise and floating about in the room, infect some unwary caller, to find lodgment in some nook or crevice, or on some shelf, moulding, sash, ornaments, curtain, drapery or other clothing, to be again dislodged from their resting places, weeks, months or years afterwards, to affect some casual visitor or new occupant, or be carried away in articles of furniture, ornaments or wearing apparel, to spread infection and carry dismay to other persons, and in other localities."

There is little wonder that, when a few years ago we sought to establish a hospital for contagious disease, the neighbors rose as one man to protest against the outrage. Scores of them now spend their Sunday afternoons in our pleasant grounds.

The discovery of vaccination against smallpox was a fine piece of scientific work but it was sadly marred by an assumption entirely unwarranted, that when performed in infancy it will protect through life. After a time this was found not to be true but this mistake more than anything else developed and kept alive the propaganda of the anti-vaccinationist. The opprobrium of our art is that preventive medicine, like its other branches, has taught much that has had to be unlearned. We ought not to be surprised that the people do not believe all we say, and often fail to take us seriously. If their memories were better they would trust us even less.

The methods of science when applied to the problems of life rarely discover the exact truth and the whole truth. Scientific knowledge is a growing plant. New leaves are continuously budding from the old. Rarely does it need pruning and its solid branches shall never be cut away. Jenner proved beyond question the protective power of vaccination, a truth which will always stand, but it remained for others to determine how universal is this immunity and how long it persists and countless other secondary truths of great importance which have been, and are, being added to the original truth. It was only the hasty assumption of the hasty philanthropist which had to be unlearned. In our own time, too, the amateur sanitarian and the social reformer and even the public health official are impatient of the slow progress of science and, taking the short and easy road which is paved with guesswork theories and unfounded assumptions, and which leadeth to destruction, they hasten to spread error before the people, which will later hamper the health officer as does now the assumption of Jenner as to the duration of vaccinia immunity, or does the theory of air-borne infection. Let us see what our health officers are teaching today. Are we doing any better than our forbears?

The old heresy about the all importance of dirt, any kind of dirt, in the causation of disease, still persists. If the writers for the weekly or monthly bulletin cannot think of anything else they can always fall back on a new sermon on dirt. Of course we all know that all human excretions are potential of danger and everything which contains our excretions or is smeared with our fresh secretions must be avoided. We know, too, that flies breed in certain kinds of dirt. It is doubtless true, too, that whatever in a general way encourages cleanliness tends to discourage those habits which favor infection. To fight all kinds of dirt instead of limiting attacks to dangerous dirt is misleading and futile. You smiled at the ancient Rhode Island essay on the relation of dirty cupboards to intolerable stomachache but is it not as bad to print,

DIRT IS D isgusting
D isfiguring
D evitalizing
D -e-a-d-l-y

"The dirt-rate of a city is a big factor in determining its death-rate."

"A vigorous anti-dirt campaign would

do the city more good than any other kind of an 'anti' campaign of which we are able to conceive—more good morally, physically, healthfully and eventually with respect to its reputation."

Another:

"To clean up the city means to clean out disease."

"Indifference about dirt produces high death-rates from preventable disease."

"Conspicuousness for habits of cleanliness means conspicuousness for good health and a low death-rate."

A picture bulletin shows adjoining yards, one shiftless and dirty, the other lovely with flowers, with the mottoes, "Dirt and disease go hand in hand." "Clean up for health's sake."

The public will thus believe that, when the streets are swept, the rubbish removed from the cellar and yard, the garbage cremated instead of dumped, and the spring housecleaning done, the city's death-rate will be lowered. When they find it is not, they will not believe the next issue of the bulletin which tells them that antitoxin cures diphtheria.

A poster shows "Household weapons against dirt and disease," a broom, shovel, rake, scrub brush, wash tub, bath tub and set basin and other things. The legend runs, "The main line of defense against dirt and disease lies in the home." Are we expected to shovel up bacilli and sweep out spirochetes? Will the wash boiler prevent the baby from catching whooping-cough or measles? The bath tub is inscribed the "cradle of cleanliness." "Bathe often and give the pores a chance to breathe." Here is either a remarkable use of the English language or a remarkable physiological discovery. It will not be disputed, I think, when I say that there is not a bit of evidence to show that it makes the slightest difference to our health (except for the tonic effect of a cold bath) whether we get into a tub once a day or once in three months. The individual drinking glass, the individual towel, and running water for washing the hands, are necessary to prevent infection, but they found no place in this picture bulletin. May we not safely infer that the artist was not a thinking animal?

A recent bulletin has a picture of a crowded lodging house dormitory with the subscription "A breeding place for germs." Pretty discouraging, is it not, for those of us who have been trying to eradicate the superstition of bygone ages?

Another form of dirt which appeals to the publicity man is dust. Now, there is one kind of dust which is dangerous, that is sharp mineral dust, but that is not dirty dust. It is the dust of the street and home that is attacked in the monthly bulletin. A cartoon shows the dust of the street falling on fruit, candy and ice-cream and a little boy in the throes of stomach-ache presumably caused by eating thereof. No evidence has yet been adduced to show that disease ever is spread in this way and much has been adduced to show that it is not. But under the influence of this campaign of publicity, some communities, which feel too poor to furnish free antitoxin, are spending money to keep dust off the ice-cream and bananas. Another bulletin says, "Avoid home dust." It "often causes disease." The fact is that there is so little evidence that street dust and house dust, except perhaps near careless consumptives, is dangerous, that the less we say about the matter the better.

So, too, in the present state of our knowledge of the relation of the air to disease, knowing that the old theory of exhaled poisons has been demolished, that germs rarely float in the air, that we are still in profound ignorance as to the relation of humidity to disease, that most of the supposed effects of foul unventilated rooms have been shown to be due to temperature and odors, is it not better, when our best students of the subject have little to offer but surmises, to refrain from such teaching as,

"Ventilate, you Lobster! Ventilate!"

"Pure air is the best life insurance."

"Get good air and you will get good health."

Another says,

"No one would think of drinking water that had been used for bathing purposes, but many of them go on breathing over and over again air that has been

breathed by themselves and other people; air that is literally saturated with the effete products of respiration, emanations from the skin and filth carried on clothing and in foul mouths."

"People have been educated to refuse to eat from tableware that has not been properly cleansed, but offer no objection to a second-hand atmosphere for breathing purposes."

"They will keep their skin clean with soap and water and then pollute their respiratory tract with a polluted atmosphere."

"Many of these deaths are closely akin to suicide; many others are closely akin to murder. How much longer shall the slaughter go on? Radical changes have been made in the street cars and some of the theatres. Much remains to be done."

"Some of the hotel banquet halls are incubators for grippe, pneumonia and consumption."

All of this is absolutely mis'eading.

A cartoon shows "Blithesome Mrs. Foul-Air and her Deadly Offspring—several cheerful skeletons labeled "Tuberculosis, Pneumonia, Influenza, Bronchitis, and Colds" and another editor names la grippe, sore throat, catarrh, colds, bronchitis, pneumonia and tuberculosis as due to lack of ventilation. "You can't see," he says, "the insidious enemy that lurks in the fetid atmosphere."

"Not even contaminated water is more dangerous to the human system than the air that is breathed over and over until its life-sustaining properties have been replaced by foul poisons given off by the human system."

While some men are striving to learn the truth, and solve by scientific methods the difficult problems of disease causation, the publicity man, as blithesome as mistress "Foul-Air," spreads broadcast pestilential errors which date back a half a century or more.

While we feel quite certain that the pneumococcus is the chief causative agent of pneumonia, pathologists and epidemiologists are still uncertain as to the relation of all the causative factors. The carrier, partial immunity, auto-infection, contagion predisposing causes, routes of infection, strains of varying virulence, offer countless problems still unsolved. No one knows just how pneumonia is caused—except the publicity man. He says,

'Pneumonia is a dirty house disease; it is developed in illy-ventilated houses, not in the pure air of out-doors as many people believe. You can't contract pneumonia in pure air; you can very easily contract it in impure air."

Another,

"Be careless about the air you breathe and you stand a good chance of being numbered among the 3,000 citizens who, in all likelihood, will fill pneumonia graves within the next five months."

Still another,

"From now until about the middle of April the pneumococcus will get in its deadly work. It flourishes in bad air, whether in workshop, factory, store, school room, home, or street car. The air of a closed house is foul, stagnant and disease breeding."

Again,

"One of the prominent men of the country died several weeks ago of pneumonia. A day or two before his illness developed he attended a banquet, and was exposed to an over-heated, close, polluted atmosphere. Two prominent citizens attended the same banquet and were made ill, but escaped pneumonia One was 'laid up' for ten days, the other for two weeks."

Our food, by the popular writer, has always been considered a source of great danger, and to attack adulterations is to receive the plaudits of the multitude. A city which boasts of having recently put its health department on a scientific basis publishes:

"Pure food is as important to health as pure air. The authorities, to whom is committed the duty of protecting public health, have a serious responsibility to discharge at this point. They must rigidly enforce the laws against the sale and offering for sale of decayed and decaying food products, without fear or favor. This we propose to do, but we are charged with destroying some food that is salable at cheap prices. Cheap food may be,

and often is, the most expensive food to buy. The poor must be protected against so-called cheap food, which may be partially decayed and dangerous to health. It never pays to run any risk in the food supply of a city. Our slogan is—"Pure food for———."

A cartoon shows Death pouring adulterants into soups and sardines while a lovely Red Cross nurse, labeled "Health," is dealing out cans marked P–U–R–E. The truth is that adulteration, except in a few instances, is an economic, not a health problem. As to partially decayed foods we know nothing about their relation to health. While inspection may be demanded on esthetic grounds there is no evidence to show that inspection prevents disease. The clean handling of foods is most desirable from a sanitary standpoint but real cleanliness is most difficult of attainment. Much that appears is carelessly written and the emphasis is placed on the wrong thing, as when dust absorbs all the attention and nothing is said about dirty hands. Exaggeration has its way as when we are told that "Dirty ice-cream is a big factor in summer diseases." It is safe to say that the writer neither knows nor cares whether this is true or not.

Some remarkable physiological principles are at times published.

"Lost—One perfectly good pair of kidneys somewhere between Comfort Street and Affluence Boulevard stations on the Road to Wealth. Will gladly pay all my millions for their return.—Mr. I. M. Sorry-Now, 13 Experience Place."

Is it not a comfort to know that the etiology of chronic nephritis has been so well worked out?

Here, too, is news about immunity. If true we may as well give up our vaccine laboratories.

"When we lead a healthy normal life, breathing good air, exercising enough to make a keen blood circulation, eliminating properly and eating our food with a zest, we are at a high point of immunity. Then it is that certain substances within the body make charges against the poisons or toxins and also kill the germs that are responsible for the toxins."

While I have questioned some of the allegations which have been made against the house-fly as a bearer of disease, I am perfectly willing to admit that he does at times and in places become a factor of importance in the spread of fecal-borne diseases. He is also a very dirty and disgusting insect. This is enough. Why call the fly "deadlier than the tiger or cobra" or "the most dangerous animal in the world?" It is news to most of us that "Napoleon could not retain his hold on Egypt because of the fly," and "that many diseases of obscure origin doubtless were caused by fly contamination." The same bulletin says that,

"An eminent medical authority has recently figured out that the fly as a carrier of the germs of typhoid fever annually costs the people of the United States for sickness, medical expenses, lost time and funeral expenses the enormous sum of three hundred and fifty millions of dollars!"

We ought to make this accurate mathematical gentleman chairman of our section on vital statistics.

The following, while interesting reading is somewhat misleading in its etiology.

THE FLY

"He has his birth in the manure, crawls forth and loiters in the sewer, and, smeared with deadly typhoid germs, he leaves his brother maggot-worms, unfurls his dainty wings of silk and dumps his microbes in the milk, where their huge numbers mount and mount, increasing the bacterial count, until they reach the food supply some woman feeds her 'baby-bye.' The fly comes gaily unto us, his feet all gummed with poison-pus, and singing clear his song so sweet, alights and cleans them on the meat. He gathers scarlet fever spores and leaves them on the walls and floors: he is not proud, and oft will stoop to carry heavy loads of croup, and place it where its awful death may come and go with baby's breath. Oh, do not call him indolent! He calls that summer day misspent in which he fails to load the breeze with the live germs of some disease; and if he finds them not, though hurt, he'll be content with just plain dirt."

We would all like to get rid of the fly, but do we really know any practical way of doing it? Is there a flyless city? The bulletins are free with advice, but how good is it? One cartoon purporting to show "How typhoid flies are made" gives mutton chops as their only breeding place. The chief emphasis is usually laid on swatting the fly. This must be practiced on the hibernating insect. To kill one is to kill 350,000,000. Prizes for dead flies, fly traps, poison, and all sort of schemes for handling stable manure are taught us over and over again in infinite variety. Why not wait until some one finds out whether they will work before telling the people that they will work.

One great trouble with the publicity man is an inordinate desire to get in on the ground floor. When he hears something new he tells it without waiting to learn whether it is true. Untried schemes of all kinds are put forward as confidently as if they were as sure as vaccination. It is not so very long ago that the sanatorium was preached as the most important factor in fighting tuberculosis while now many specialists think quite otherwise. Many prophesied the speedy eradication of the disease and not a few fixed the year as 1915. Great speed will be required to finish the last lap. Let us take warning and ever bear in mind that only an exact science can forecast the future. Within a few years various plans of excreta disposal for the rural districts have been published in health bulletins as solving the problem. The editors could not wait to try them. Now they have all proved disappointing and of far from general application. I was recently shown a scheme for the disposal of house drainage about to be published by a state board of health, and when I asked if it had proved satisfactory was told that it had not as yet been tried. Better be the last city to publish a useful sanitary measure than be the first to teach one that later proves a failure.

Many other remarkable things about disease we learn from the weekly bulletins. Thus we read,.

"One of our school teachers whose little brothers had died of croup contracted from wet feet some years before, very carefully inspected the little tots in her room for wet feet and found quite a number."

We have plenty of arguments for preserving the teeth without making such a statement as "The use of alcohol to excess does not cause as much disease as neglected teeth." The prohibitionists might well demand the proof.

One bulletin unique in its scientific accuracy yet makes the slip that,

"Every cold in the head . . . comes from a transfer of excreta." Unfortunately we know very little about the group of afflictions called colds and I am not aware that a single type has been definitely proved to be caused by a specific bacterium. On the other hand we do know that one important kind is produced by the pollen of plants and is not contagious.

Probably there are few who agree with me entirely as to the value of terminal disinfection, but I am sure there are fewer still who would assent to the following recent publication.

"Properly and efficiently done, fumigation is a great factor in the prevention of contagious diseases. It is the only means of checking its spread. A number of cities have spent thousands of dollars to stamp out epidemics in this manner. In fact, it is the only way in which this can be accomplished."

Another bulletin, after recommending the burning of a pound of sulphur in each room at spring housecleaning time, says this is, "a simple method of home disinfection that is most thorough and far-reaching in its results as regards disease prevention. . . .

"This simple method is given in the belief that every housekeeper will use it to the extent that all sleeping apartments, closets where clothes are kept, and such other rooms as require fumigation at housecleaning time will be fumigated in this manner to prevent contagious and infectious diseases from entering the home."

Doubtless there are some who will think all this hypercriticism. The slips are small, they say, and seldom occur. It is

true that one may scour many pages of some publications without finding anything to offend, but others show them in nearly every issue. Some, perhaps, are of little moment but who would be so rash as to say that because a lie is a little one it can do no harm. As no one can follow the flight of an arrow, so the poet tells us, or know into whose heart the spoken word shall sink, so no one knows whose mind will be confused by the error which carelessly flows from our pens. One cannot expect scientific accuracy in publicity, a very good friend, who is a forceful writer of telling articles, said to me. I made no decided answer then, but the more I think of it, the more decided I am, that scientific accuracy should be insisted on. Our science itself is so inexact that we cannot afford to swerve one hair's breadth from it. One can hold steadfast to scientific truth and yet avoid, absolutely, all pedantry and scientific jargon. Clear, forceful and catchy writing is worse than useless if it fails to teach the truth and the truth only. So far as it departs from this our health literature approaches that of the fake medicine factory—and perhaps does more harm. The space writer is the curse of our day and generation and especially in our business.

For the sake of those who come after, stop filling your columns with tommy-rot, hot air and dope. Do not be always seeking novelty. Most that is new is bad. There are plenty of old truths which all of our 100,000,000 people have not yet learned. If you have nothing to write do not write it. Remember that bulletins were made for man and not man for bulletins.

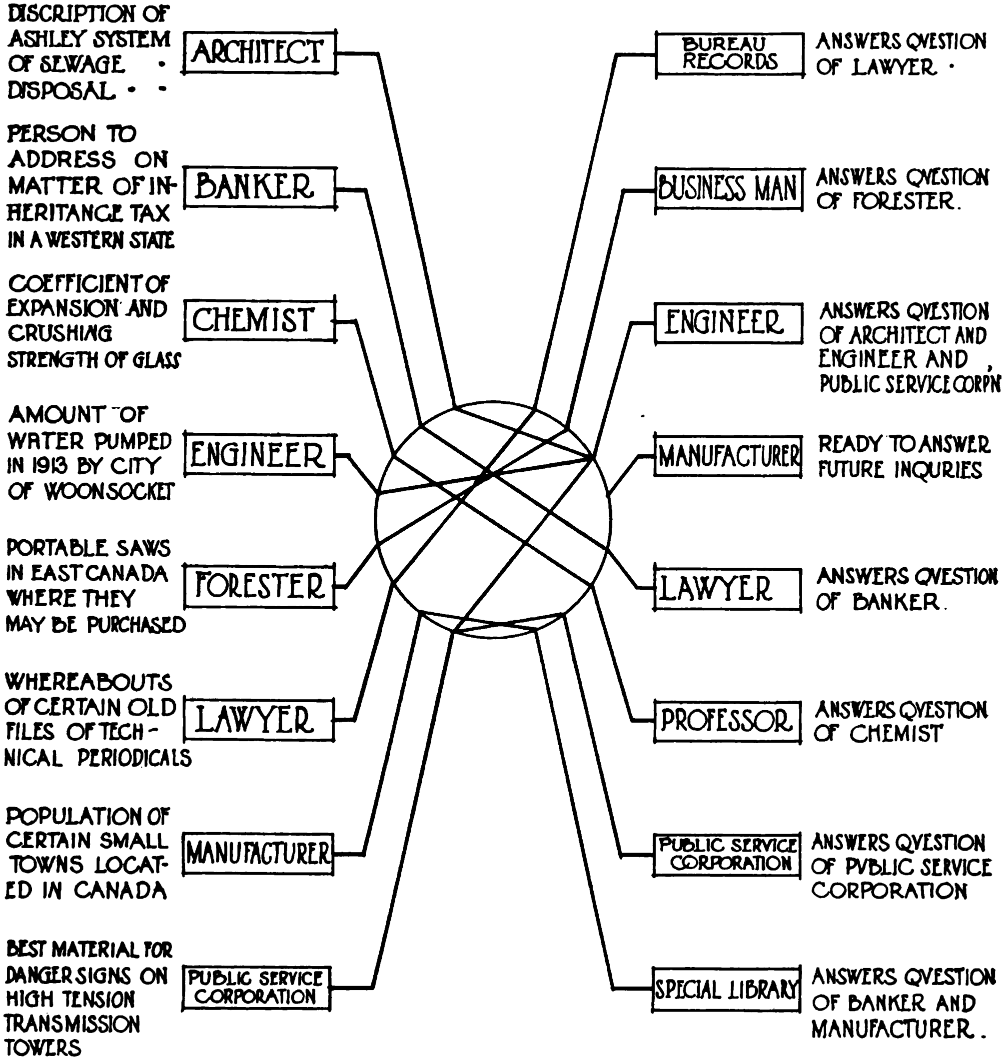
Better pay your publicity man for doing nothing than for writing something which is not so. Careless writing betokens the lazy writer. Seek diligently the truth and faithfully publish it.

THE MISSION OF THE GULL

In an article on the "Value of Birds to Man," published in the report of the Smithsonian Institution, James Buckland of London says: "The presence of the gull is essential to man's health. While the bird fulfills many useful offices—such as destroying larvæ in land along the seaboard and in eating enemies of fish that are exposed during low tide—its chief function in the economy of nature is that of scavenger of the harbors and of the littoral, just as vultures are the scavengers of the mainland. The wholesale destruction of gulls for their plumage in Yucatan was followed by a great increase of human mortality among the inhabitants of the coast, which mortality was irrefutably due to the loss of the birds that had kept the harbors and bays free from the decaying matter which the sea is constantly casting ashore."

MOUNT WILSON OBSERVATORY

No portion of the funds of the Carnegie Institution of Washington has been more fruitfully applied than that which created and has maintained the Mount Wilson Solar Observatory, in California. As Professor Hale, the director of the observatory, says in his last annual report, he and his colleagues have heretofore devoted a large share of their time to devising and testing methods and apparatus, and these are now being applied to solar investigations which were formerly studied with altogether inadequate means. In a forthcoming book, "Ten Years' Work of a Mountain Observatory," Professor Hale will outline the results attained during the first decade of experiments and observations. During the year 1914, which began a second decade, many noteworthy results were achieved. A beginning was made in the application to solar phenomena of Stark's capital discovery of the effect of an electric field on radiation. In stellar astronomy discoveries have been made which promise to furnish the means of determining a star's distance simply by measuring its brightness and the relative intensities of certain lines in its spectrum. Spectroscopic studies in the splendid laboratory attached to the observatory have shed new light on astrophysical problems. The report above mentioned enumerates no less than fifty-nine definite achievements as the fruit of a single year's work.—*Scientific American.*



A BUREAU OF INFORMATION

THERE is an organization in Boston, which is perhaps the only one of its kind in the country, whose business it is to supply general information to its subscribers, oftentimes within a few minutes after the query has been received.

It is not to be understood that this bureau goes into questions of a fundamental or technical character relating to processes, etc., but it does at least aim to put the questioner in touch with the expert best fitted to give the desired information.

As indicated by its name, the Boston Coöperative Information Bureau, it has immense resources of information among its members who cover a broad field of endeavor. The spread of questions received by the bureau covers almost every subject conceivable, but perhaps the greater number of them have reference to articles in publications, both foreign and domestic.

The chart shown on this page gives something of an idea of how the bureau operates.

LIQUID AIR AND ITS PROPERTIES

SOME REMARKABLE EXPERIMENTS WITH LIQUID AIR, WHICH, ALTHOUGH POWERFUL AS A PRIME MOVER, HAS FEW APPLICATIONS IN THE PRACTICAL ARTS

In his book "The Triumphs and Wonders of Modern Chemistry," Mr. Geoffrey Martin gives an instructive description of liquid air. "Our grandfathers," he says, "would have been much astonished if they had been told in early youth that they would live to see the invisible air in which they lived reduced to clear sparkling liquid which boils on ice, freezes pure alcohol, and burns steel like tissue paper. They would perhaps have been even more astonished if they had been told that in their time men would even succeed in freezing the air, in turning it into a white solid ice-like mass, so intensely cold that its touch burns like the fiercest fire. We propose to lay before the reader a brief account of the magnificent modern researches which have led to these wonderful results."

"To produce liquid air in the laboratory," says Dewar, "is a feat analogous to the production of liquid water starting from steam at a white heat, and working with all the implements and surroundings at the same high temperature. The problem is not so much how to produce intense cold as to save it when produced from being immediately levelled up by the relatively superheated surroundings." After a century of continual effort human perseverance and endeavor have at last succeeded in overcoming these difficulties with the result that liquid air may now not only be produced in gallons at a time, but it may be kept for weeks in wonderful heat impervious vessels first introduced into general use by Dewar.

The problem of keeping this liquid air when obtained was a very serious one. It is similar to the problem of keeping water from boiling away when surrounded on all sides by a white hot furnace. Dewar solved the difficulty by placing it in a doubly walled vessel, the space between whose walls had been previously carefully evacuated. The empty space forms an almost perfect insulation and in such vessels liquid air may be kept for weeks at a time. It may even be transported in such vessels for thousands of miles with but little loss, although surrounding the liquid air on all sides is a medium almost red hot in comparison to it. Think, too, of the curious possibilities that the invention of these heat impervious "Dewar Flasks" opens out. Centuries hence, when the world's supply of coal is almost exhausted, and firing has become immensely dearer, such vacuum-jacketed vessels may come into general use for keeping liquids hot or cold, and even for making the walls of houses impervious to heat or cold. Instead of making hot tea several times a day, the family may in future times make it, perhaps, once or twice a month, and store the hot fluid in one of these vessels and serve it out boiling hot from day to day as required.

Liquid air is nearly as heavy as water and quite as clear and limpid. When seen in the open air it is always muffled in a dense white mist that wells up over the edge of the vessel in which it stands, and rolls along the floor in beautiful billowy clouds. It presents, in fact, much the same appearance as a mass of boiling steaming water. The intense cold of the liquid causes the moisture in the surrounding air to condense as clouds, and it is this which gives rise to the curious phenomenon.

No other substance in the world, excepting liquid hydrogen and liquid helium,

is as cold as liquid air; and yet the hand may be dipped into it fearlessly. The sensation is only that of a soft cushion about the hand. Such it really is. The hand is so hot in respect to liquid air that a layer of vapor surrounds it and prevents the liquid from coming into actual contact with the flesh. However, the hand must not be allowed to remain in the liquid for more than an instant, for if the liquid were actually to touch the flesh a severe injury like a burn would result which sometimes takes months to heal. Even a few drops retained on a man's hand will sear like a white-hot iron. For this reason liquid air has been used in surgical cases where cauterization is necessary. It is stated to eat out diseased flesh quickly and rapidly. Indeed a well-known New York physician seared out a cancer by its means and entirely cured a difficult case. The early hopes entertained of its use in this direction do not, however, seem to have been realized. It is curious to note that over two hundred years ago, the burning effect of great cold revealed itself clearly to Milton's poetic imagination. In his "Paradise Lost" he thus grandly describes the Land of Absolute Zero;

"A frozen continent
Lies dark and wild, set with perpetual storms
Of whirlwind, and dire hail which on firm land
Thaws not; but gathers heap, and ruins seem
Of ancient pile: all else deep snow and
ice. . . . The parching air
Burns frore, and cold performs the effect of fire."

The grandest poetic and scientific imaginations are closely akin, and consequently, whatever science may unveil, the chances are that in the world's best poetry will be found hints of every discovery.

The intense cold of this strange fluid may be illustrated by a number of remarkable experiments. Thus melting ice, cold as it seems to us, is actually 180° C. above the temperature of liquid air. It is consequently as hot in respect to it as fat frying in a saucepan is in respect to our bodies, or as molten lead is hot in respect to boiling water. If, therefore, liquid air be poured upon ice it will fly off hissing like water from red hot iron. If some liquid air be placed in a metal tea-kettle and then set upon a block of ice, the air at once begins to boil violently, and a white vapor as of steam rushes from the spout and lid. If the kettle be placed over a fire of burning coals the heat of the fire causes the liquid to evaporate more rapidly and a stream of vapor shoots out of the spout to a great height. It looks like steam from a kettle of boiling water. If water be placed in the kettle as soon as the air has boiled away, it may be taken out as ice, while at the same time the bottom of the kettle will be found coated with solid carbonic acid and ice, frozen from the fire. And all this happens with the fire glowing only an inch or so below. It is very surprising, too, to see one's breath, blown into an open can of liquid air, sent back instantly with its moisture congealed into a miniature snowstorm. Even a jet of scalding steam is instantly frozen, for between steam and liquid air lies an abrupt temperature drop of nearly 300° C. Mercury is instantly frozen into a solid shining metal like silver. This solid metal is as hard as granite, and can be cast into swords and tools. Thus, if a little pasteboard box be made in the shape of a hammer head and filled with mercury, and, after suspending in it a wooden rod to serve as a handle, if the whole be immersed in liquid air, in a few minutes the mercury will be frozen so solid as to form a veritable hammer which can be used for driving nails into hard wood.

Such experiments as these bring forcibly before the mind the abyss of cold which reigns in space about us. By contemplating the intense coldness of liquid air—itself a hot body in comparison to the cold of space—we are enabled to realize clearly how exceedingly hot the world's surface would appear to a being dwelling in the cold and darkness of the waste regions of the universe. Such a being landing on the surface of

our planet would be shrivelled up like a piece of meat in an oven. If he managed to escape in time back to his cold gloomy abode, he would doubtless, like Mr. Wallace, sit down and write a book proving conclusively that no living beings could possibly exist on such a scorching world as the earth.

We must remember, too, that the earth's surface, like every other hot body, is radiating away heat and light into space, only our eyes are not sensitive to perceive it. In Le Bon's words: "Down to the absolute zero of temperature all bodies incessantly radiate waves of light invisible to our eyes, but probably perceptible by the animals called nocturnal and capable of finding their way in the dark. To them, the body of a living being, whose temperature is about 37° C., ought to be surrounded by a luminous halo, which the want of sensitiveness of our eyes alone prevents our discerning. There do not exist in nature, in reality, any dark bodies, but only imperfect eyes. All bodies whatever are a constant source of visible or invisible radiations, which, whether of one kind or the other, are always radiations of light."

Air is liquid at $-180°$ C., and as we have seen, if we raise its temperature above this, it will boil just as water does when heated above 100° C. Steam, in fact, bears the same relation to water that ordinary air bears to liquid air. Since the earth's surface is nearly 200° C. above the temperature at which liquid air boils, it acts in the same way towards this fluid as a coal fire acts towards water. Hence we have only to expose liquid air to the heat of the furnace about us and in which we live, and it boils instantly, producing, like water surrounded by a fire, a vapor which expands and produces power. We can therefore use liquid air as a motive power.

The pressure exerted by liquid air in regaining its gaseous state is simply enormous. Hardly any closed vessel could withstand it. This becomes easily intelligible when we consider that a single cubic foot of liquid air contains condensed within it about 750 cubic feet of air at ordinary pressures and temperatures. If, therefore, it be left to absorb heat from the surrounding air it will expand by this amount, and, if prevented from so doing by being confined in a closed vessel, it will exert a pressure at ordinary temperature of over 10,000 lbs. (four and a half tons) on the square inch. If heated the pressure would amount to from ten to thirty and more tons on the square inch. No ordinary boiler could resist such gigantic pressures. Yet one can realize easily that if this force could be confined and controlled it would give rise to an immense amount of power. It has indeed been suggested that liquid air could be used for driving high-speed engines, for flying machines and other purposes where great power combined with lightness is essential. The great obstacle to its use, however, is the freezing effect it produces. The moisture of the air is rapidly deposited as ice upon the machine, especially round the orifice from which the jet of extremely cold air emerges. This soon closes the exit-tube and stops the machine. There are other disadvantages, too, which cannot be discussed here. The expansive power of liquid air may be demonstrated easily by pouring a little into a tightly plugged steel barrel. In a short time the plug will be expelled with a loud detonation, and sent whirling for hundreds of feet into the air. Some liquid air poured into stout steel or copper tubes which are then firmly sealed will in a short time cause them to explode like shells, sending the metallic fragments hurtling in all directions with great force.

Although liquid air is as harmless as water, and so long as it is not confined, cannot of itself explode, yet it is an extraordinary fact that, when mixed with other substances, it can form an explosive comparable in intensity to dynamite itself. Thus, in some experiments carried out by Mr. Trippler of New York, a bit of oily cotton waste, soaked in liquid air, was placed inside an iron tube open at both ends. This was laid inside a larger and stronger tube, also open at both ends. When the waste was ignited by a detonating fuse the explosion was so

terrific that it not only blew the smaller tube to pieces, but it burst a great hole in the outer one as well.

Indeed in Germany practical use has been made of this fact in blasting in coal mines. Cotton wool impregnated with coal dust and steeped in liquid air is rammed into a hole drilled in the coal, and the whole exploded by a detonator in the ordinary way. The explosion which ensues is as effective as a dynamite one, but without its risks; for should a charge fail to explode in a few minutes all danger is past; because there remains only cotton and coal dust when the liquid air has evaporated. This is a valuable feature of its use, since many lives are lost annually in attempting to remove dynamite charges which have for some reason or other failed to explode.

This property of liquid air is due to the fact that it contains oxygen in a very concentrated form. When it is mixed with a substance which will burn rapidly in oxygen, and a detonator is applied to the mixture, an explosively rapid combustion sets in, in which the sudden intense heat generated causes an instantaneous and violent rush of gas so that the whole goes off like so much dynamite. Indeed the actions in both cases are much the same, as we shall see when we come to deal with the latter body.

As we have already pointed out, air is composed of twenty-one parts of oxygen and seventy-nine parts of nitrogen. It begins to boil at $-195°$ C., the boiling point of nitrogen. The nitrogen boils off first, leaving behind the oxygen, and so the temperature gradually rises until it reaches $-183°$ C.

The more nitrogen it loses, the bluer and at the same time the heavier the liquid becomes. This change may be shown easily by pouring a quantity of liquid air into a large glass bottle partially filled with water. For a moment it floats, boiling with great violence, liquid air being slightly lighter than water. When, however, the nitrogen has all boiled away, the liquid oxygen, being heavier than water, sinks in beautiful silvery bubbles, which boil violently until they disappear. A few drops of liquid air thrown into water will instantly freeze for themselves little boats of ice, which sail around merrily until the liquid air boils away. In this way ordinary liquid air exposed to the atmosphere becomes very rich in oxygen, and oxygen in such a concentrated form is a very wonderful substance. For instance, ordinary woollen felt can hardly be persuaded to burn even in a hot fire; but if it be dipped in this liquid oxygen, or even in liquid air, it will burn fiercely with all the terrible violence of gun-cotton. A splinter of wood, when soaked in liquid air rich in oxygen, will burn like a fiery torch with immense power, while a glowing wood splinter plunged into liquid air bursts into furious flame, and may cause the whole vessel containing the liquid air to be shattered by the heat developed. Indeed, steel itself may be burnt by liquid air. To demonstrate this a tumbler of ice is made, and it is half filled with liquid oxygen. A burning match is then attached to a bit of steel spring and the whole dipped into the liquid air contained in the ice tumbler. The steel then burns, spluttering and giving out a glare of dazzling brilliancy. Between the liquid oxygen and the burning steel are about 2,000° C., and yet the ice tumbler is not affected. The oxygen is turned into a gas before combustion begins. For liquid oxygen itself probably will not support combustion. Instead of a steel spring, an electric-light carbon red-hot at its tip will burn in exactly the same way with dazzling brilliancy. Thus the abyss of cold which prevails in liquid air does not prevent it from acting as a powerful inflaming medium.

Liquid air introduces us to a strange cold world very different from the one in which we live. All things alter their properties to an astonishing extent at these low temperatures, and the exploration of the properties of matter under these new conditions is now steadily proceeding in all parts of the civilized world. Thus iron and steel increase their tensile strength immensely, but at the same time become as brittle as glass.

WOOD PRESERVATION

Investigations on the effect of zinc chloride as a preservative for the cheaper grades of pine for structural purposes have been made by Alfred Henry Clarke of the Institute of Technology and made the subject of his graduation thesis.

The usual means of prevention is by filling the wood with a poison such as zinc chloride which is found easy of application and efficient as a preventive of rot. It has been suspected, however, that the use of zinc chloride might, in itself, impair the strength of the timber, and Mr. Clarke's research has shown that wood thus treated and kept at a temperature of 150°F. for forty days possessed about 38 per cent. of the breaking strain of untreated specimens. It often happens in factories that wood is kept at quite a high temperature for a considerable time, and under such circumstances the use of zinc chloride would have a weakening effect. These studies suggest the need of further investigation along this line.

COLOR BLINDNESS

It is only within a hundred years that color blindness has been known to exist, and it is only comparatively recently that it has been known that women are never color-blind. Color blindness is a characteristic which is inherited and passes on from one generation to another. If all the children of a color-blind father are girls, the trait remains dormant and reappears in one of every four male children of the next generation. It is, therefore, a sex link characteristic.

There are two types of complete color blindness, each of which has to do with two groups of colors—red to blue and white and black. When the color-blind man has two important colors affected, he is said to be "dichromatic." When he is only color-blind and sees merely white and black, he is "monochromatic."

In the first of the above divisions are those who are red blind, green blind and violet blind. Red blindness is most frequent. Its victims are really blind to both green and red, distinguishing only yellows and blues.

The seat of color vision is at the very center of the retina. If the retina were painted with rings like a target, the bulls-eye would contain the visual points for green, the next outer ring would be red, the third, blue, then white, and the outside ring would be black.

Some persons see colors imperfectly, but do not have true color blindness. This defect is due to the use of tobacco. There is no known way of curing color blindness.

INDEX TO SCIENCE CONSPECTUS, VOL. V

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VOL. VI 1916 No. 1

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

VOL. VI 1916 No. 1

THE HORSE AND HIS PROGENITORS

SINGULARLY COMPLETE ANCESTRAL RECORDS SHOW HOW CLIMATIC CHANGES HAVE EVOLVED THE HORSE FROM ITS EARLIEST FOUR-TOED ANCESTOR

BY W. D. MATTHEW

THERE are several reasons why the evolution of the horse is of peculiar interest. First, because as a domestic animal it is so familiar to all of us and has played so large a part in the history of our own race, in the progress of civilization. Second, because it is one of the most marvellously perfect and beautiful illustrations of animal mechanism. It is one of the swiftest of large animals, specially adapted for rapid movement over long distances, and peculiarly fitted in every detail of its structure for its particular food, habits and environment. Third, because the geological record of its evolution is exceptionally complete. Fossil horses or rather stages in the ancestry of the horse are found in the Tertiary formations of the western states as far back as the beginning of the Eocene. They present a long series of successive stages through which it can be traced back to small and primitive beginnings, little removed from that common ancestral stock to which the various kinds of hoofed and clawed animals trace their origin. Most of these stages in the ancestry of the horse are now known from numerous specimens and more or less complete skeletons of each, so that we can observe in detail the progressive modifications of structure in every bone and tooth, and reconstruct pretty accurately the form and proportions of the body.

The Skeleton of the Horse.—If we compare the skeleton of a horse with that of a man, it is easy to see that with all the wide differences in proportions the fundamental plan is the same in both. The bones correspond throughout; their relations to each other, the characteristic form, muscular attachments and processes, are mostly identical. There are wide contrasts in proportions, however, especially in head and limbs. The head of the man is extremely short, and mostly brain-case. The head of the horse is extremely long, and mostly face and jaws. The horse is long-necked and deep-chested; the man is short-necked and wide-chested. The limbs of the horse are powerful, compactly built, limited in their movement to a fore and aft direction; the limbs of the man are long, slender, loose-jointed. But it is in the feet that the contrast is greatest. The five digits of the human hand and foot are in the horse reduced to a single digit greatly lengthened out, the nails converted into broad heavy hoofs to support the animal's weight. Of the inner and outer digit, first and fifth, no trace is seen; and of the second and fourth digit all that remains is the pair of slender, pointed splint-bones which lie pressed close to the main central digit or cannon-

bone. Thus the horse is quite accurately said to walk upon the tip of its middle finger-nail; the so-called knee of the fore-leg really corresponds to the wrist of man and the hock joint to the ankle; while the true knee-joint of the hind-leg and the elbow of the fore-leg are caught up into the flank, so that they hardly appear to be joints in the free limb.

The joints of ankle, wrist and feet are in man of the shallow cup-and-ball type which allows of free movement in any direction. In the horse they are all converted into hinge-joints more or less deeply grooved—a much stronger joint, but permitting of only fore-and-aft motion.

The teeth in man are a comparatively small and simple mechanism adapted to biting off and crushing soft food. In the horse they constitute a large complex and elaborate machine for cropping and thoroughly grinding the hard wiry grasses that form its natural food.

As a domestic animal the horse is of course found in all parts of the world; it is completely cosmopolitan. Through selective breeding by man various domestic races have been evolved, adapted to different purposes, ranging in size from the Shetland pony to the great Percheron draught horse, and with considerable variation in proportion as well. Broadly speaking the breeds fall into three groups —the Arabs and race-horses, the draught horses, and the ponies. In all the different domestic breeds the structure of skull, of teeth, of feet or other characteristic parts is almost identical; the differences are in size, proportions, color and markings of skin, amount of hair and so forth.

Wild horses are almost unknown today. The so-called wild horses found in various unsettled countries are mostly domestic stock escaped from restraint; they are feral, not true wild animals. There is, however, a small horse found in the deserts of central Asia, believed to be a truly wild species, and known as Przewalsky's horse.

The *asses and zebras*, while they differ in color, in the callosities of the legs and other surface characters from the horse, are closely allied and by most writers all are included in the single genus *Equus*. Setting aside subspecies and varieties there are two very distinct species of asses, the so-called Asiatic wild ass kiang, or onager, *Equus hemionus*, and the true wild ass of northern Africa, *Equus asinus*. Of the zebras there are, besides the quagga, now extinct, three distinct living species, each with a number of varieties. These are the Grèvy, Burchell and Mountain zebra. Besides differences in length and shape of head they are easily distinguished by the color pattern, especially on the rump. In the Grèvy. the narrow vertical stripes on flank and rump are characteristic. In the Burchell species there are instead broad oblique stripes extending quite across the rump, and in continuous series with the leg bars. The third species of zebra is the Mountain zebra *Equus zebra*, distinguished by the continuance of the vertical body striping in a narrow strip along the middle of the rump, with broad oblique stripes below. The face is noticeably shorter.

The zebras inhabit central and south Africa; the true wild ass northeast Africa, the kiangs Persia, northwest India and parts of central Asia, while the Przewalsky horse is found further to the northeast. This distribution of the surviving species of wild horses is but a small remnant of their widespread distribution during the Pleistocene, the latest geologic epoch. Numerous species of wild horses then inhabited the various parts of Europe, Asia, Africa, North and South America, wherever in these continents the climate and environment were suitable. These are all referred to the genus *Equus* and differ very little in skeleton character from the domestic horse, some being practically indistinguishable. The best known fossil species in this country is *Equus scotti*.

In South America, in addition to two or three species of *Equus* in the Pleistocene, there were other horses of the genera *Hippidium* and *Onohippidium*, one-toed like *Equus* but with shorter legs, teeth of different pattern, and some peculiarities in the nasal bones.

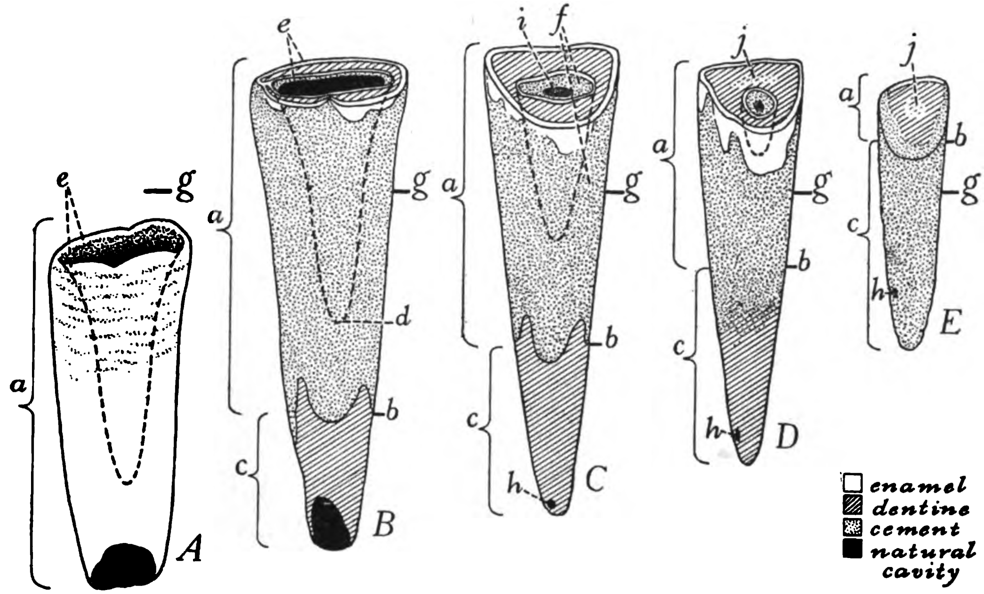


FIG. 31. Incisor teeth of a permanent set (i.[1]) showing wear and movement. Inner view. Natural size.
A. Tooth of a colt 2 years old before it has erupted. e, folded edge of enamel, unworn.
B. Tooth of horse 4 years old. a, crown; b, base of crown; c, incompleted root; d, bottom of cul-de-sac; e, worn edges of enamel; g, gum line.
C. Tooth of horse 12 years old. c, root fully grown; f, internal and external cement; h, nerve foramen; i, natural cavity in cement.
D. Tooth of horse 17 years old. j, "dental star."
E. Tooth of horse 33 years old.

All these wild horses of the new world became extinct before the coming of the white men. Most of them apparently had disappeared before the close of the Glacial Epoch. In the Old World most of the wild species likewise became extinct, but some survive in the modern asses and zebras, and others were the progenitors of the domestic horse. The origin of the various breeds has been traced by different authors sometimes to one, sometimes to three or more species corresponding to the three chief modern breeds.

Teeth of the Horse.—In order to understand the evolutionary history of the teeth it will be necessary to examine more carefully the structure of the teeth in the modern horse. If in a skull of the horse the bone is cut away from in front of the teeth, it becomes evident that they occupy most of the face in front of and below the orbits. The teeth are pushed up from the roots as fast as they wear off at the grinding surface. The incisors, or cropping teeth, form a convex row, which works with a shearing action fore and aft. The teeth have a deep valley or infolding between the inner and outer surfaces. As they gradually wear down toward the base of this valley or pit it becomes smaller and shallower and finally disappears from one after another of the teeth, until in extreme old age it has gone completely. On this account this pit, known as the "mark," can be used to tell the age of a horse, but not very accurately after eight years. Between the incisors or cropping teeth and the cheek teeth or grinders is a long gap technically known as the diastema. In the middle of this gap in the upper jaw of the male is the wolf tooth or canine, but in the female the canine teeth are entirely absent.

The cheek teeth form on each side a row of six large complex grinders above and below. The first three correspond to

the bicuspids in man, the premolar teeth of other mammals, and are preceded in the young by temporary or milk-molars. The last three are true molar teeth and have no milk predecessors. The permanent teeth, molars and premolars are all very much alike, the intermediate ones so much so that it is difficult to tell them apart. They push up from below as they wear off at the top, and in extreme old age are completely worn down to the roots. This in fact limits the age of a horse.

Pattern of the Cheek Teeth.—These grinding teeth have a very characteristic construction, which is best understood by studying the unworn tooth. In this tooth before the cement has covered it we can see that there are two crescentic ridges (the paracone and metacone), two inner crescentic ridges (paraconule and metaconule) and a flattened inner pillar (the protocone), and two smaller crests, hypostyle and hypocone, at the back of the tooth. The ends of the inner crescents are looped up to the outer pair by connecting bridges which show up as soon as the tooth becomes a little worn, and the inner pillar is similarly looped up to the paraconule. Between the inner and outer crescents are deep valleys or pits which in fact extend down to the base of the tooth. These are called the cement lakes or fossettes. A deep valley or infolding also extends in between the protocone and hypocone. On the outer face of the tooth are three prominent ridges, the parastyle, mesostyle and metastyle. These various crests or ridges are inherited in the horse from its remote ancestors, and correspond with the cusps or cones of the short-crowned teeth in most primitive mammals; but they have been enormously drawn out in the lengthening of the crown.

As the tooth crown breaks through the jaw the valleys between the crests become filled and the whole tooth covered with a heavy coat of cement. This material, deposited on the outer surface of the enamel by special secreting glands, is softer than enamel and about as hard as the dentine that forms the substance of the tooth inside its enamel coating. As the tooth wears the enamel edge always stands up as a ridge, flanked on one side by dentine, on the other side by cement. This is a very effective mechanism for grinding the food, and has been imitated in various other animals.

Structure of the Foot.—The other feature most worth especial attention in the horse is the construction of the feet.

We have already seen that the horse is a one-toed animal, the third or middle digit of fore and hind foot being enlarged, elongated and specialized to support the whole weight. In place of the five bones of the palm and instep in man the horse has a long straight cylindrical shaft, the cannon bone, with a pair of small slender tipped splint-bones lying close against its back, generally about two-thirds as long as the cannon bone. These are the remains of the second and fourth digits; of the first and fifth there is no trace left. The three phalanges or finger bones of the middle digit are short, massive, and the terminal one bears the hoof; there are no phalanges on the side toes.

The bones of the knee and hock joints, that is to say the wrist and ankle of the horse, are the same in number as in most other animals save for the absence of the trapezium which should support the first digit or thumb in the fore foot. But they are much changed in form, the facets being modified into hinge joints allowing only fore and back movement.

The Series of Tertiary Ancestors.—We have now to take up the evolution of the horse as it is presented to us in the geologic record and to observe the gradual development of these characteristic and peculiar structures, especially in the teeth and feet.

The Pleistocene species, as we have seen, are substantially like the modern ones in all except minor matters of proportion and small details of tooth pattern.

In the successive formations of the preceding Tertiary Period, we find a long series of stages through which we can trace back the ancestry of the horses to small and primitive progenitors. The genus *Equus* makes its first appearance at the end of the Tertiary in the later

Pliocene formations of the old world. With this exception all the horses of the later Tertiary are three-toed, the splints of fore and hind feet being developed as complete toes, provided with the full number of phalanges and small but perfect hoofs. These side toes are small and slender and did not reach the ground in the ordinary step of the animal. They were evidently useless rudiments or vestiges, like the dew-claws of some ruminants and of dogs. The teeth of these later Tertiary horses are shorter crowned, less completely provided with cement, the pattern different from that of *Equus*. The animals were notably smaller, the largest of them scarcely as large as a domestic ass. And all these differences from the modern species become greater as we trace them further back. In the Oligocene or Middle Tertiary we find more primitive stages. The side toes, although still slender, reach the ground and help to support the weight of the animal. The teeth are quite short-crowned and have no cement. The animals are about the size of a sheep. In the Eocene or Early Tertiary are still earlier stages, the side toes being almost as large as the middle toe, and in the fore foot there are four complete digits. In the very earliest Tertiary Paleocene we find no animals that we can regard as direct ancestors of the horses, but as all the Paleocene animals are five-toed, with a very primitive pattern of short-crowned teeth and in other respects conform to the theoretical common stock from which all the various kinds of placental mammals are derived, we may suppose that the undiscovered ancestors of the horse in the Cretaceous and earliest Tertiary were likewise five-toed, walking upon the sole of the foot, with tritubercular molars not unlike those of modern lemurs, tree-shrews and some other very primitive living mammals, and that from this primitive stock the horse and all the widely diverse types of modern animals are descended.

Looking at the evolutionary history more in detail, it is convenient to start from these primitive beginnings, and trace the development of the race upwards. As it is a record of facts we need hardly waste time on the theoretical ancestry, but begin with the earliest actual appearance of the horse phylum in the geological record.

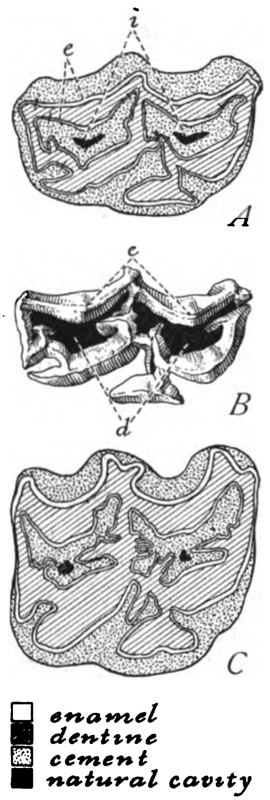


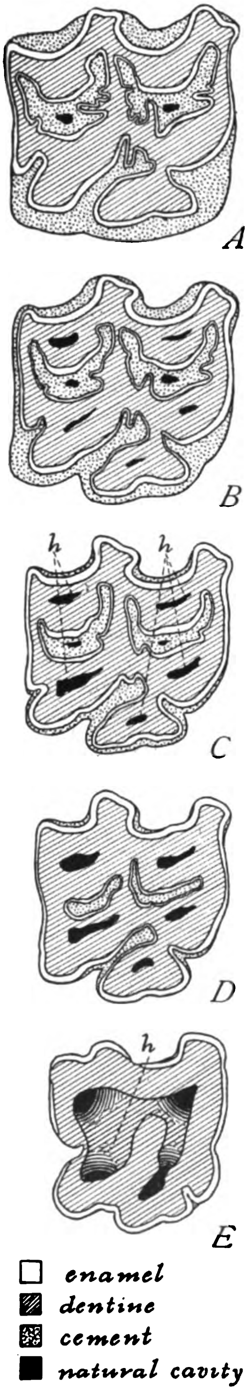
FIG. 33. Wearing surface of upper grinding teeth. Natural size.

A. Worn surface of deciduous molar (d. m.^{4}) of colt about 6 months old. e, exposed enamel edges; i, natural cavity in cement.

B. Unworn surface of deciduous molar (d. m.^{4}) of colt about three months before birth, showing only enamel. d, cul-de-sac to be filled later with cement; e, apex of folded edge of enamel.

C. Premolar (p. m.^{3}) of horse 8 or 9 years old.

Eohippus, the Oldest Known Ancestor.— First comes the Four-toed Horse, *Eohippus* or *Hyracotherium* of the Lower Eocene. It appears quite suddenly at a certain level in the Wasatch formation. Thousands of specimens have been secured at and above this level by expeditions of the American Museum; below it not so much as a tooth. Most of these specimens are pieces of jaws; a few are skulls and partial skeletons, and one a fairly complete skeleton, discovered in 1911. In this earliest known stage of the four-toed horses we find in the hind feet three complete toes and in addition tiny splints or vestiges which represent the first and fifth digits. They thus point back clearly to a preceding five-toed stage in the hind foot. The



fore foot shows four complete well-developed digits. But neither in this nor in any subsequent stage in ancestry of the horse, nor indeed in any member of the order Perissodactyla (horses, tapirs and rhinoceroses) recent or extinct, have we been able to discover any actual trace or indication of the inner digit or thumb of the fore foot. You will find it represented as present in *Eohippus* in most of the published descriptions and diagrams but that is an error, based on a mistaken identification of certain fragmentary foot bones studied by Professor Marsh many years ago. No Perissodactyl has any trace left of the pollex. Presumably the Perissodactyls are descended from Cretaceous ancestors which had a thumb; but such ancestors have not yet been found, so that while we have traces of five toes in the hind foot of the earliest known stage, we have only the four toes in the fore foot. The trapezium, however, is always present.

The teeth in *Eohippus* are forty-four in number, the full series being present in both upper and lower jaw. (The incisors are little simple cutting teeth, quite small. Behind them is a diastema in the middle of which are the small sharp canines or wolf teeth in both upper and lower jaw.) The premolars are smaller than the molars and quite different in form, being simple trenchant or cutting teeth, of which the last two are beginning to change shape and become more like the molars. The molars are short-crowned, with small conical cusps on the surface partly united into cross-crests with a pattern in the upper jaw somewhat like the Greek letter π, while in the lower jaw they have two cross-crests, already beginning to change into a pair of crescents. These teeth may be compared with those of the coney or dassie among modern animals, or with the modern tapir, and served to chop or break up soft food, but were not at all grinding teeth.

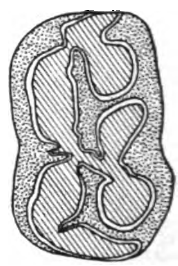


FIG. 35. Lower premolar (p.m.$_{3}$) of horse 8 or 9 years old.

The next stage of four-toed horses is from a later horizon in the Lower Eocene, and is best known from the skeleton discovered by Doctor Wortman in the Wind River valley in 1880 and described in Cope's Tertiary Vertebrata. It is the classic four-toed horse of the text-books. In this stage the tiny rudiments of the first and fifth digits in the hind foot are believed to have disappeared.

Orohippus of the Middle Eocene.—In the next stage of the Tertiary formations, the Middle Eocene, we find the genus *Orohippus*. Remains of this animal are fairly common in the Bridger formation of Wyoming. A fine skeleton was secured for the American Museum in 1905 by Mr. Granger. In *Orohippus* the fore foot has four complete digits and no trace of a pollex, the hind foot three complete

FIG. 34. Upper grinder (p. m.^{4}) of horse 10 or 11 years old cut in 5 sections; showing pattern of enamel at various ages. C, h. Branches of the pulp cavity. E, h. Pulp cavity.

digits and no trace of first and fifth; but the middle or third digit in each foot is somewhat larger relatively to the others than the Lower Eocene four-toed horses. The teeth, while very like those of *Eohippus*, show a distinct advance in that the third and fourth premolars are larger and more like the molars in pattern, the fourth lower premolar being almost indistinguishable. The molars are somewhat more distinctly crested than in *Eohippus*.

In *Epihippus of the Upper Eocene* all these changes are a little further advanced. Skulls and partial skeletons have been found in the Uinta formation of Utah, but a complete skeleton has not yet been found. However, the various specimens agree in showing that the middle or third digit is relatively larger, and that the premolar teeth are more like the molars. The last upper and the two last lower premolars are indistinguishable from the molars, the others are partly molariform except the first, which in all the series has been growing progressively smaller and simpler. The cresting of the molars is also a little further advanced.

The Small Three-Toed Horses of the Oligocene.—These four-toed horses of the Eocene make a closely connected series. There follows a considerable gap, for the next stage, in the Lower and Middle Oligocene, is *Mesohippus*, in which the outer digit of the fore foot is reduced to quite a small splint, and the middle digit in both fore and hind foot is considerably larger than in *Epihippus* and has taken on the characteristic cylinder-shape of a cannon bone. The side toes, however, are still large enough to help support the weight of the animal. The teeth show a stage in evolution beyond that of *Epihippus* in that three premolars in upper and lower jaw are completely molariform. The crests of the molars are also slightly higher.

The next stage, *Miohippus* of the Upper Oligocene, is closely allied to *Mesohippus*, but of larger size, and slightly more advanced in teeth and feet.

The Miocene Three-Toed Horses. — During

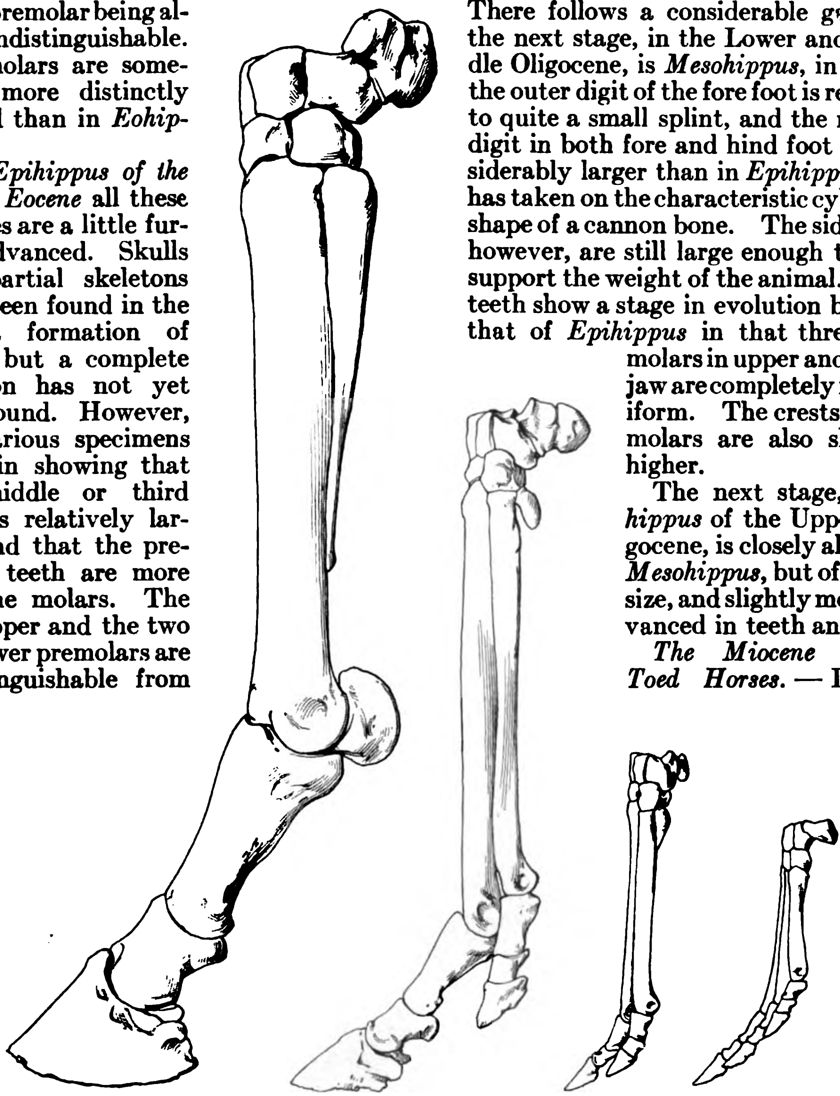


FIG. 2. Evolution of the Fore Foot. Principal stages. (Right to Left.)
1. Four-toed horse *Eohippus*. Eocene Epoch.
2. Early three-toed horse *Mesohippus*. Oligocene Epoch.
3. Later three-toed horse *Merychippus*. Miocene Epoch.
4. One-toed horse *Equus*. Pleistocene Epoch and Modern.

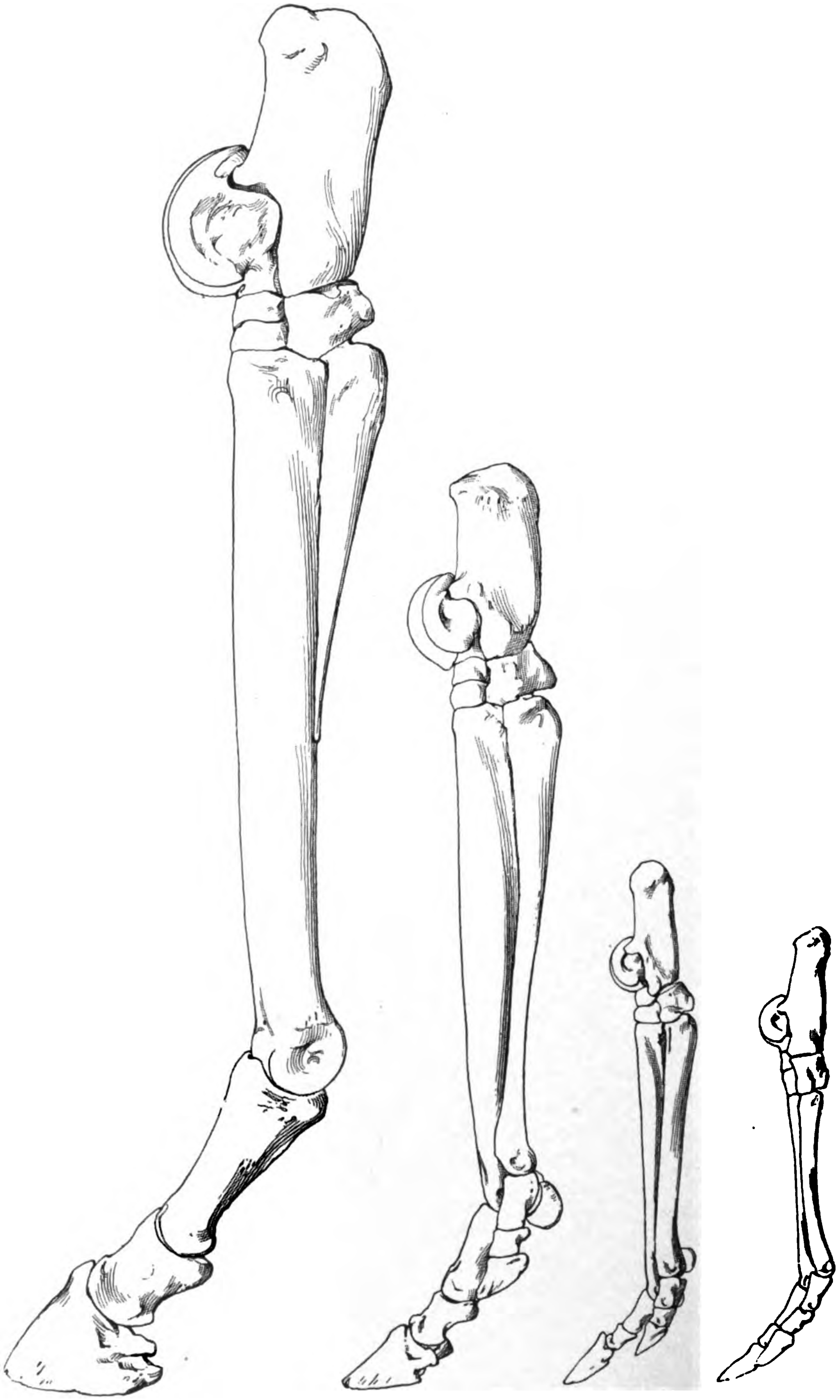


FIG. 3. Evolution of the Hind Foot. Principal stages (Right to Left). 1. *Eohippus*, Eocene Epoch; 2. *Mesohippus*, Oligocene; 3. *Merychippus*, Miocene; 4. *Equus*, Pleistocene and Modern.
Outer views showing middle and outer digits. Note progressive reduction of side toe (digit IV) from a well developed digit to a splint bone.

the next epoch of the Tertiary, the Miocene, the horses enter upon a course of comparatively rapid evolution, progressing more rapidly toward the modern type, and also branching out into several races, some more advanced in one character, some in another. The beginnings of this may be seen in the ten or twelve species of *Parahippus*, the Lower Miocene genus. This genus is distinguished by the first appearance of cement on the teeth, only a thin skin on the earlier species, but considerable amount on some of the later ones. The crowns of the teeth are also progressively higher, and on some of the teeth there is always the beginnings of a bridge across the inner valley, never complete, but marking the first stage of a change from the cross-crests of the earlier species to the inner crescents of the later horses. The side toes are distinctly more reduced than in *Miohippus*, and barely reach the ground, while the middle digit is becoming more of the later type (rudiment of fifth toe smaller).

In the Middle Miocene appears the next stage in the evolutionary series, *Merychippus*. In this animal the teeth are heavily coated with cement, and the pattern of the crowns is changed to the two pairs of crescents on the upper molar, with an inner pillar which is usually separated from the crescents, although in some species it is more united. But the pillar is always round, not flattened oval as in the modern horse, and the height of the crown is not much more than the width of the tooth. In *Merychippus* the milk premolars carry very little cement, and are very like the permanent premolars of *Parahippus*. The feet are very like those of *Parahippus*, slightly more advanced.

In the Upper Miocene we find three closely related genera, apparently descended from *Merychippus*, all advanced toward the modern horse type, but some more progressive in one, some in another character. These are *Hipparion* (including *Neohipparion*), *Protohippus* and *Pliohippus*. All of them have longer crowned teeth than *Merychippus*, and in all the milk molars are longer crowned and more heavily cemented. In some species of each genus the side toes are very much reduced, the shafts of the metapodial bones being hardly more than threads, while in other species there is little progress in this respect. The upper teeth of *Hipparion* are long and but little curved with strong mesostyle, and the inner pillar in some species is flattened. The enamel is strongly crumpled in little folds on the borders of the cement lakes, as in *Merychippus* but more so. In all these characters *Hipparion* comes nearer to the modern horse than do *Protohippus* or *Pliohippus;* on the other hand the inner pillar or protocone is separate nearly to the base of the tooth, whereas in these genera, as in *Equus*, it is united to the inner crescent or protoconule.

In *Pliohippus* the teeth are equally long but the molars are strongly curved, the mesostyle is not as heavy, there is no crumpling or folding of the enamel, and the cement lakes are decidedly larger than in *Equus*. The inner pillar is united even more strongly than in *Equus* to the adjoining crescent, but it is never flattened, and the bridge is not exactly in the same place. In *Protohippus* the teeth are very like those of *Pliohippus* but with smaller lakes, and the protocone sometimes partly flattened.

Each of these three genera has been regarded as the direct ancestor of *Equus*. My own conclusion is that *Equus* is derived from *Hipparion*, but not from any of the better known species, and that the South American *Hippidium* and *Onohippidium* are derived from *Pliohippus*, again probably not from the known species.

Another interesting feature in these Miocene horses is the pits or fossæ on the side of the face. These are absent in the Eocene horses, as also in *Equus*, but are characteristic of most of the Miocene and Pliocene genera, and in the South American *Onohippidium* there is a very deep fossa. The object of these pits has been disputed; some authors consider that they lodged scent-glands; others believe that they were simply for attachment of

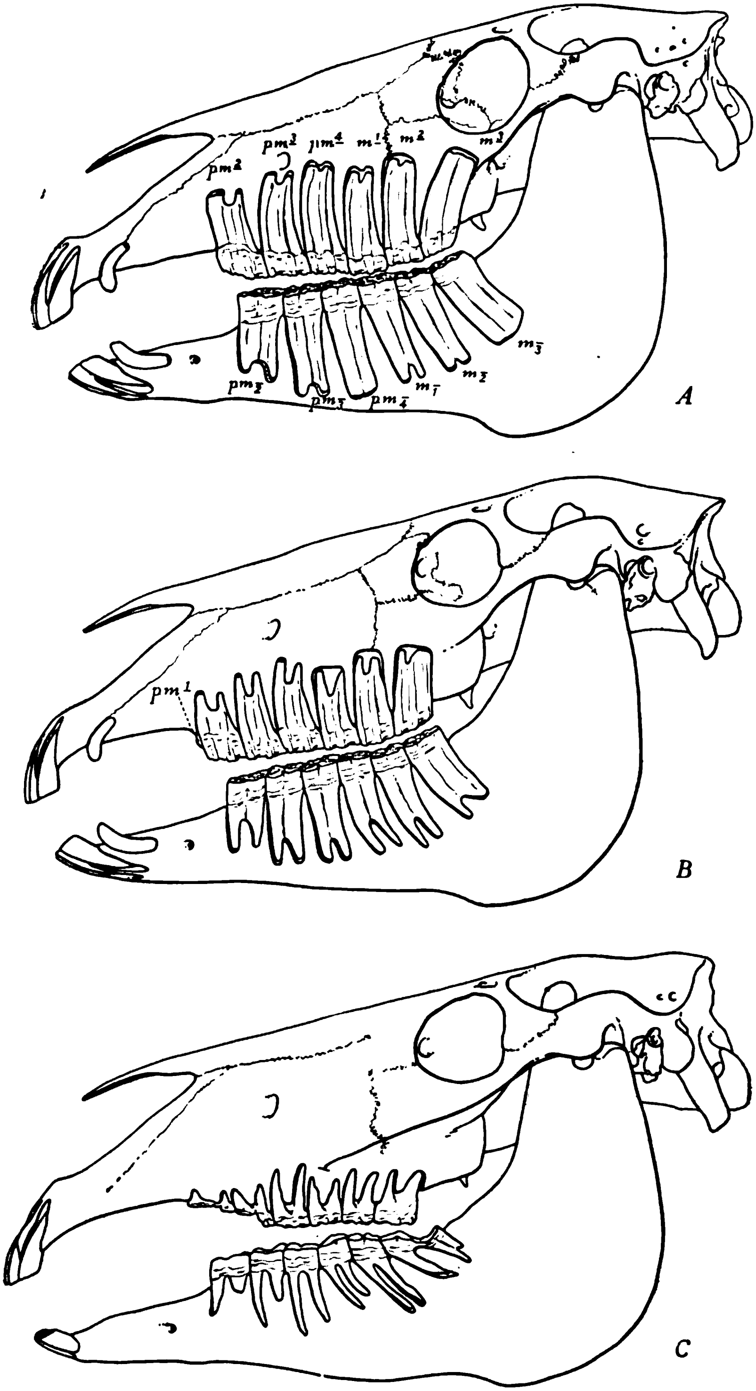


Fig. 37. Dental Battery of Adult Horse

A. Skull 5 years old. Permanent teeth all in use.

B. Skull 8 years old. Crowns reduced in length by wear and roots grown longer. Vestigial p.m.[1] present in this individual.

C. Skull 39 years old. Crowns almost worn away. Lower molars incline forward. (The canines are absent in the female.)

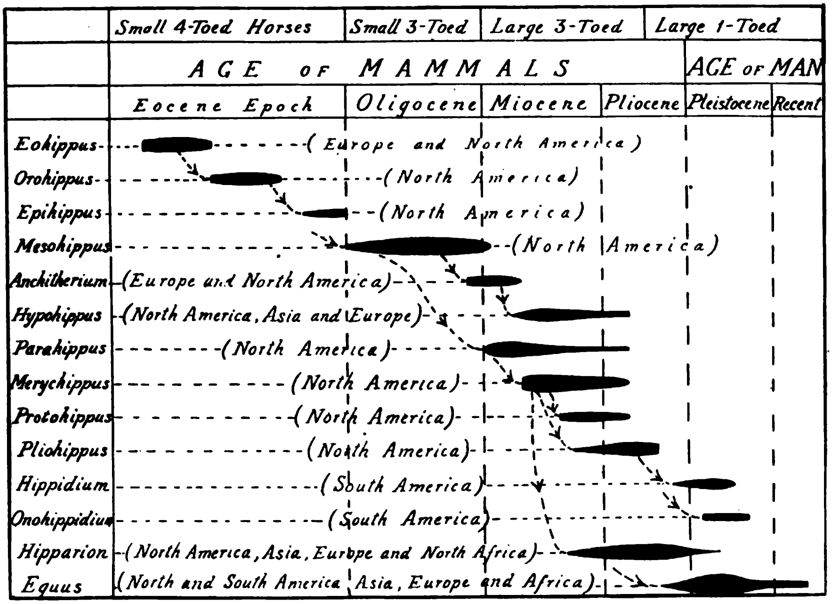


Fig. 16. Geological and geographical range of ancestors of the horse. The position and length of the heavy black lines show the occurrence and range of each genus in the successive geologic epochs, while the thickness of the lines indicates relative abundance. The dotted connecting lines with arrows indicate the genealogy.

strong muscles moving a flexible upper lip or proboscis.

Pliocene Horses.—The Pliocene record of the evolution of the horse is not as complete as we would like; and it is for this reason that we are so uncertain as to which of the Miocene horses is most nearly in the direct line of ancestry. The Lower Pliocene horses are very close to those of the Upper Miocene, but somewhat more progressive. Fragmentary material from the Middle Pliocene serves to show that the two genera *Hipparion* and *Pliohippus* continued on, increasing in size, and approaching nearer, the one to ***Equus***, the other to *Hippidium* so far as I can judge from a few teeth. True *Equus* appears possibly as early as the Upper Pliocene, certainly at the beginning of the Pleistocene in North America. *Hippidium* has never been certainly identified in this continent; the species referred to it are more probably *Pliohippus*.

Is it a Direct Ancestral Series?—The ancestral series which we have now reviewed is the North American succession. How close and continuous it is may be seen by comparing the 12 stages in the upper molars. So far as the genera are concerned it is fair to say that they are in direct genetic or lineal succession. I do not think that this can be said of the species. That is to say, we cannot select a series of species occurring in geologic succession and all directly intermediate in every particular from one genus to the other throughout the series.

In most cases we must conclude that the later stage is descended from unknown species of the preceding stage. This is of course what we should expect, for the law of chance will make it very improbable that the few species of each genus which we happen to have found out of the many that must have existed in different regions at that time, should always include the direct ancestor of the following genus. In most instances each genus will be descended from undiscovered species of the preceding genus.

Centre of Dispersal.—Where these unknown species lived is a most interesting

problem. In considering it, we have to keep in mind that the regions where Tertiary fossils have been found are really quite limited. We speak of *Orohippus* inhabiting North America, but in truth all we really know is that it inhabited parts of southwestern Wyoming. Practically all our knowledge of the older Tertiary faunas of the northern world is derived from certain formations occupying limited areas in Wyoming, Utah and New Mexico, and certain others still more limited in the adjacent portions of England, France and Belgium. In the middle and later Tertiary our knowledge rests on a more extensive regional basis. But it is nowhere near enough to give us adequate data to estimate the geographic range of different species, until we come to the Pleistocene. We can judge of the regions where the new types were evolving by inferences from the geographic and taxonomic relations of the known forms. But all such conclusions are necessarily hypothetical.

Tertiary Equidae in Europe.—There is in western Europe a Tertiary series of ancestral horses, which, until the American series was discovered, was the nearest approach to an ancestral line. The oldest member is *Hyracotherium*, contemporary with *Eohippus*, and practically identical. In the Middle Eocene *Pachynolophus* and other genera are found, apparently side-branches from the direct line. In the Upper Eocene are *Lophiotherium*, *Anchilophus* and others, all of them representative of side-branches which have evolved along lines parallel to the direct series, but not ancestral. Some of these continue through the Oligocene, and then disappear. In the earliest Miocene appears *Anchitherium*, not derivable from any of these European races, but apparently from *Miohippus*. This genus is common in the Lower and Middle Miocene, but in the Upper Miocene gives place to *Hipparion*, another type apparently of American origin. *Hipparion* in turn is replaced by *Equus*, and again we find that the American species of *Hipparion* are more nearly in the ancestral line than are those of Europe. As the American series is decidedly more direct than the European series it is fair to conclude that the Western United States where it is found was decidedly nearer to the centre of dispersal of the Tertiary horses than was Western Europe. That is to say, the centre where the successive stages in the evolution of the horse evolved, and from which they spread out in different directions, was in Northeastern Asia or boreal North America. Western Europe in the early and middle Tertiary was a shifting archipelago more or less separated from the main mass of the northern continents, while North America afforded a broad and open way from the north, and was probably united with Asia during most of the Tertiary. It would seem that the immigrants from this centre of dispersal were able to spread to central North America in a pretty continuous series of waves of migration but that only three or four of these migration waves reached Western Europe. *Hyracotherium*, *Anchilophus*, *Anchitherium*, *Hipparion* and finally *Equus* in Western Europe are new invading types, each closely related to the contemporary new invading type in North America. In the intervals between these renewals of affinity, the races tend to more or less divergent evolution in the two regions.

Cause of the Evolution.—While the existence of continental connections afforded the opportunity for migration and dispersal of the successive stages from *Eohippus* up to *Equus*, I think that the fundamental impelling cause of the migration is the same as that of the evolution itself, namely climatic changes. Those who are familiar with Professor Ellsworth Huntington's work, will recall how closely he has connected human migration movements with cycles of climatic change. I believe that the migrations of Tertiary animals were also caused by climatic changes driving them out in all directions from the central Holarctic regions where, on account of their nearness to the poles, the oncoming changes of climate were first and most severely felt.

And to this same cause, the secular

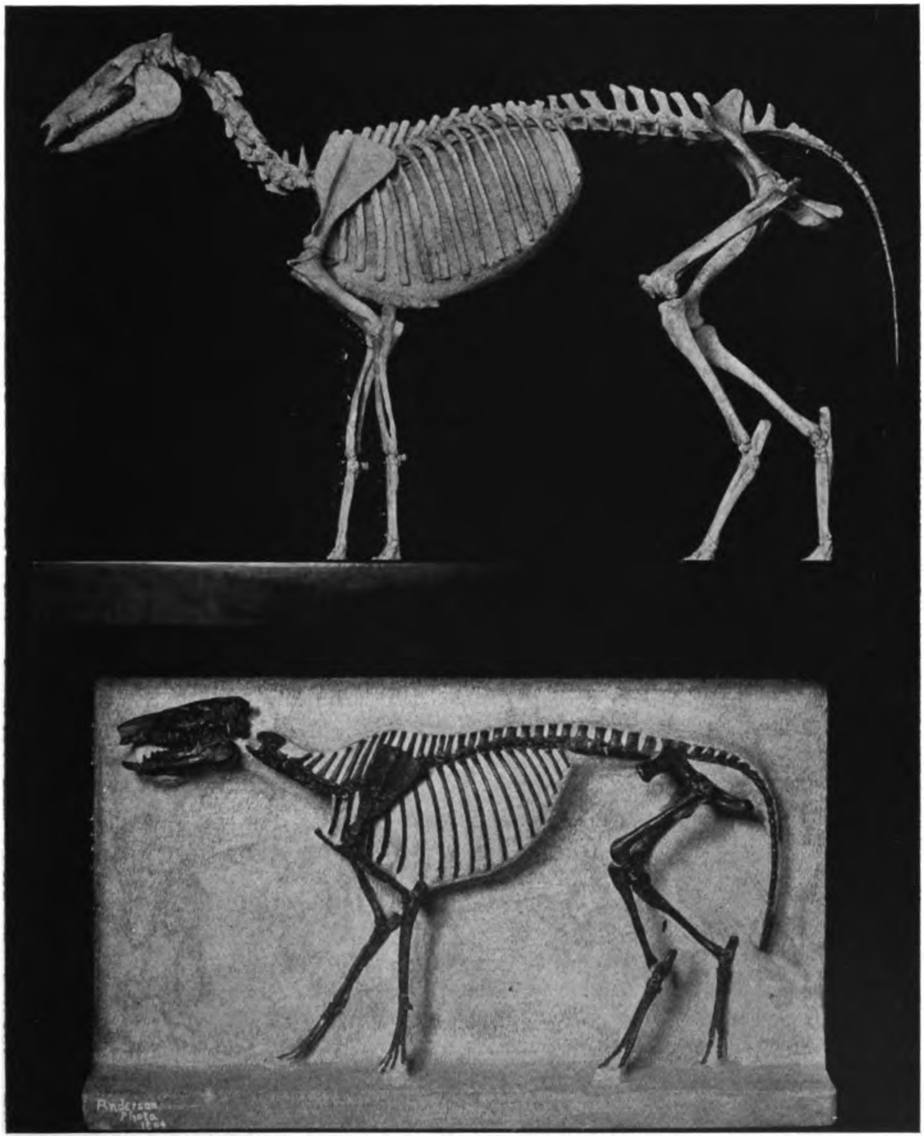
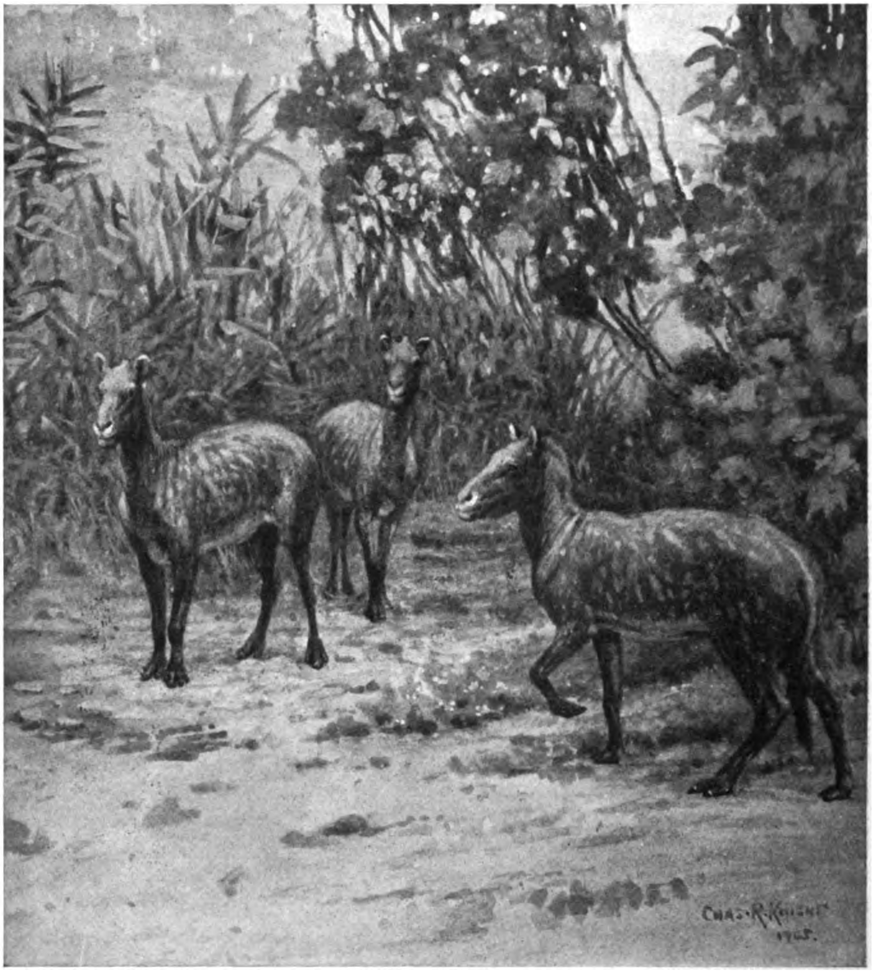


Fig. 8. Little three-toed horse (*Mesohippus bairdi*) from the Middle Oligocene of South Dakota. American Museum, No. 1492.
Four-toed Horse (*Eohippus renticolus*) from the Lower Eocene of Wyoming. American Museum, No. 4832.



Eohippus, the Four-toed Horse
Reconstruction of the earliest known Ancestor of the Modern Horse, discovered in the bad lands of Wyoming.

change in climate during the Tertiary from uniformly warm moist semi-tropical conditions to the contrasted climates of the present day, with highly varying seasons, cold at the poles and arid in the interior of the great continents—to this change I conceive that the evolution of the horse was fundamentally an adaptation. For such a change in climate involved the replacing of dense forests by open plains and arid deserts. It resulted in the replacement of trees and shrubs by grasses, of animals adapted to the irregular obstructed travel of the dense forest by animals adapted to the open level surfaces of the grassy plains, of browsing by grazing animals. It brought about the adaptation of the animals of the great open interior plains to swift movement over level ground to traveling long distances for water and endurance of extremes of cold, to feeding upon the hard wiry grasses of the arid plains. And the evolution of the horse from its little four-toed browsing brush-haunting ancestors of the Eocene went hand in hand with the change in climate, the spread of the grasses and open plains, and the progressively harsh environment of the far north.

THE TILEFISH

THE attention which has recently been given to the tilefish, which is now being taken in large quantities from New England waters, makes its recent local history interesting. This fish was discovered in 1879 off Nantucket, and a specimen was sent to the United States Fish Commission, which pronounced it a new species. The fish was found in large quantities and had excellent food qualities, but just as tile fishing promised to become a profitable industry the fish were apparently exterminated in some mysterious manner. In the spring of 1882 an area of 170 miles long and 25 miles wide off New England was covered by dead tilefish. The displacement of the Gulf Stream is given as an explanation.

The tilefish lives at the bottom and requires a rather high temperature. The warm water of the Gulf Stream no longer extended to the bottom and the fish perished in the cold water.

SPREAD OF FUNGUS BLIGHT

THE Pennsylvania Department of Forestry has been making exhaustive investigations with a view of finding out the means of the dissemination of spores of blight fungus which are the causes of numerous tree diseases. There is most convincing evidence that insects are principally responsible for the spread of spores, although a large number of them are, of course, carried by the wind. The result of these investigations suggest also that the spread of other plant diseases is directly traceable to the action of insects.

THE "NOBLE" GASES

HOW THE "NITROGEN" OF A GENERATION AGO HAS BEEN MADE TO YIELD SIX, AND POSSIBLY SEVEN ELEMENTS AND THE VALUE OF THIS DISCOVERY TO CHEMISTRY

BY HENRY P. TALBOT

FROM the earliest days of quantitative chemical experimentation the atmosphere has been the subject of frequent investigation. The discovery of oxygen as a separate entity resulted from the independent researches of Priestley in England and Scheele in Sweden about 1774, and nitrogen had been recognized as a new gaseous substance by Rutherford in 1772. The part which these two gases play in the atmosphere was demonstrated a little later, and for more than a century the literature contains innumerable records of physical and chemical measurements based upon the assumption that these two elements constitute the sole essential constituents of the gaseous envelope of the earth. Other substances, such as moisture, ammonia, and carbon dioxide, are, to be sure, universally present, but are accidental components, varying in amount according to local conditions, while oxygen and nitrogen are to be found in approximately constant proportions, no matter where the specimens of air may be collected.

Such was the universal belief when, in 1893, Lord Rayleigh, an English physicist, undertook to review the measurements of some of the natural constants of the more common permanent gases, among them the density of nitrogen gas. He was profoundly astonished to discover that "nitrogen" obtained from the atmosphere after removal of the other constituents, according to the then accepted methods, was distinctly heavier, volume for volume, than nitrogen obtained from the decomposition of chemical compounds of which it is a component. The differences were much too large to be accounted for by errors in manipulation or observation, since these were accurate to about one part in ten thousand, while the discrepancies in weight were of the order of one part in two thousand.

When this announcement was made public, speculation as to the cause of the observed difference in density was rife, but it soon became highly probable that a search must be made for a new element in "atmospheric nitrogen," as the residual gas which remains after the removal of the other constituents from the atmosphere is now called. To this search Lord Rayleigh and Professor (now Sir William) Ramsay addressed themselves.

They first employed a method which was a repetition of work done nearly a century before by Cavendish. An electric discharge was passed through air in the presence of an alkali. This causes the oxygen to combine with a part of the nitrogen and the products of the combustion are absorbed by the alkali. In this way the oxygen can be removed, and the residue is "atmospheric nitrogen." Nitrogen is a comparatively inactive element in a chemical sense, but it can be made to combine directly with certain of the metals, such as magnesium, and by repeatedly passing the residual gas over the metal until no more diminution in volume occurred, they obtained a small quantity of a gas which was twenty times as heavy as hydrogen (taken as a standard) whereas nitrogen is only fourteen times as heavy. This final residual gas was found to amount to a little less than 1 per cent. by volume of the original air. These results were confirmed by other and different procedures, and in 1895 the

two co-workers felt justified in announcing the discovery of a new element, to which they gave the name argon, the inert; a name which later investigation has justified since argon has resisted all attempts of the most varied character to induce it to enter into chemical combination with any of the other elements.

It is interesting to note that Cavendish just missed the discovery of this element, for in the record of his experiments we find that, when sparking a mixture of nitrogen with an excess of oxygen, he obtained a residue of which he says: "If there is any part of the phlogisticated air (now called nitrogen) of our atmosphere which differs from the rest and cannot be reduced to nitrous acid, we may safely conclude that it is not more than one-one hundred and twentieth of the whole." The residue was undoubtedly argon, and it is remarkable that this record should have passed unnoticed for more than a century.

The chemist conceives that any given element is not indefinitely subdivisible by chemical agencies. He terms the ultimate particles atoms and further conceives that compounds are formed by the union of atoms of different elements. It is not possible to determine with accuracy the absolute weights of these atoms in terms of any units of weight in common use, but it is possible to determine the relative weights of the atoms of different elements, in terms of the weight of the atom of hydrogen taken as a standard. When a new element is discovered, almost the first concern of the chemist is to fix a value for its atomic weight on this hydrogen scale. Although argon, as already stated, forms no chemical compounds, it was found possible from its physical constants to fix upon a value for its atomic weight with much probability of truth. But a fresh difficulty then presented itself, namely, that this new element did not fit into the so-called periodic system of the elements. Mendelejeff has found that, if the known elements are arranged in the order of their atomic weights, those elements which have generally similar properties recur periodically in the resulting system. But argon, with an atomic weight 40, which was the value found for it, would be out of place; that is, it would be associated in the system with very dissimilar elements. Since repeated determinations of the atomic weight made upon different specimens of the gas confirmed the figures first obtained, and since, according to the periodic system, the value seemed to be too large, a search was begun for possible small admixtures with the argon of a second new element with larger atomic weight.

At this time it was recalled that nitrogen had been found in the gases occluded in certain minerals, and it was suggested that argon might also be found in these gases. Professor Ramsay collected a considerable quantity of the gases from a mineral called cleveite, and these did contain argon, but they also yielded another new element, although not the one for which they were searching. In this discovery the spectroscope played the principal part. It is known that highly heated gases give out light which when examined with the aid of a prism is found to be different from sunlight, in that it does not produce a continuous spectrum. The heated gases emit light of certain definite wave-lengths, which appear as bright lines in different parts of the spectrum. These lines can be charted with great exactness and have a constant position for a given element. Sir William Crookes, who made the spectroscopic examination of the gases from cleveite, reported the presence of an element yielding lines identical with those shown in the spectrum of the sun's chromosphere during an eclipse, and ascribed as far back as 1868, by Lockyer, to an element which he called helium. Later measurements confirmed the identity of the lines in the spectrum of the new gas with those of helium and density determinations showed that this element has an atomic weight of 4 on the scale indicated above. It could not, therefore, account for the discrepancy in the atomic weight of argon, but its discovery clearly pointed to the existence of other elements of the general character of argon. It

should be noted in passing that the similarity of the spectra of argon and nitrogen, as well as its inert character, largely account for the failure to detect its presence in the atmosphere for so long a time.

Thus stimulated, the search for other inactive elements was continued. A considerable quantity of argon from the atmosphere had been laboriously collected, and preparations were made to liquefy it and subject the liquid to fractional distillation, that is, to allow it to evaporate slowly, collecting the gases evolved in separate portions or "fractions," the first of which would contain a larger proportion of that element which boiled away most readily, just as alcohol tends to boil away first from a mixture of alcohol and water in the radiator of an automobile. These "fractions" were then separately liquefied, and each, in turn, refractionated, in this way gradually separating the more volatile from the less volatile constituents. The same procedure was applied to the residues obtained upon the evaporation of liquid air. Indeed, without the use of liquid air, and liquid hydrogen, as refrigerating agents, or the skill in manipulation of liquefied gases obtained through the handling of liquid air, together with the perfection of the evacuated double-walled Dewar flasks, the isolation of the different inert gases would not have been possible.

The separation by means of fractional distillation had to be supplemented by other physical methods, namely atmolysis, or diffusion through minute openings; and later, the adsorption of gases in the pores of willow-charcoal at low temperatures. The less the density of a gas the more readily it diffuses, hence by passing a mixture of gases of different densities through something like the stem of a clay pipe, the lighter gas is made to pass through the pores at a more rapid rate than the others and may be collected from the outside.

By combinations of these three procedures, fractional distillation, diffusion, and selective adsorption in charcoal, it has been possible to isolate and identify five members of this wholly unique group of gases, often called the "noble gases" because of their apparent disinclination to associate themselves with other elements. The elements are helium, neon, argon, krypton, and xenon. The first two are lighter, the last two heavier, than argon. Notwithstanding the discovery of the two latter elements, the anomalous position of argon in the periodic system is still unexplained, since they are not present in sufficient amounts to alter appreciably the atomic weight determination. The other members fit into the periodic system without difficulty.

A sixth member has recently been added to the group in the discovery of niton, the emanation given off by radium compounds in the first step of their disintegration. This has been obtained in amounts weighable only by specially constructed balances of remarkable accuracy, but, notwithstanding the great difficulties to be overcome, its atomic weight has been determined with probable accuracy, and its chemical inertness established. There is some reason for suspecting the existence of a seventh "noble gas," lighter than helium, which because of its small mass would not probably remain in the earth's atmosphere but would be attracted by the larger heavenly bodies, and would even then probably be found only in the outer portions of their atmosphere. Spectral lines have been detected from the sun's corona, emitted by some substance outside the zone of hydrogen or helium, and these lines are not identical with those of any terrestrially known element. The name coronium has been tentatively assigned to this element,—just as helium was named by Lockyer in 1868,—and it may be another "noble" gas.

Five members of this group, helium, neon, argon, krypton and xenon are found in the atmosphere, and niton is probably present in most minute amounts. The proportions of the other gases seem to be about as follows:

Helium, 1: 185,000; neon, 1: 55,000; argon, 1: 106.3; krypton, 1: 20,000,000; xenon, 1: 170,000,000.

Liquid air is the source of all of these gases today, except helium, which although present in liquid air is more read-

ily obtained from the gases occluded in certain minerals, as noted already. Neon has offered the greatest difficulties in purification.

The discovery of a series of elements without any chemistry, such as had been unknown and possibly unimagined, was, of course, sufficient to excite great scientific interest, after a certain period of incredulity as to the validity of the discovery had passed. Their scientific importance is further enormously enhanced by the discovery that helium is a product of the disintegration of radioactive materials, and that all terrestrial helium probably owes its origin to this source. There is no direct evidence at present that any of the other inert gases, except niton, have a similar origin, but the final conclusion on this point has yet to be reached.

Helium remained unique for some time after its discovery as the only gas which it was impossible to liquefy. Even Dewar, so skilled in such methods, was unsuccessful, but Onnes, building upon the foundation laid by Dewar, has succeeded, and has produced liquid helium in considerable quantities. Its boiling-point is about 4° above absolute zero, that is, about −269° C., and Professor Onnes has conducted a series of most valuable investigations upon the effect of this temperature (the lowest at our command) upon physical phenomena, notably electrical phenomena. One of the most striking results of his investigations is his demonstration that an electrical current induced in a lead ring placed in liquid helium continues to flow for a long time after the exciting cause is removed; that is, electrical resistance nearly disappears at that temperature. It is evident that this opens an immense field for experimentation and speculation.

Argon is now comparatively easily obtainable from liquid air, provided it is not necessary to purify it from the small amounts of the other inert gases, which do no harm in argon for technical purposes. It has already found commercial use in the "argon lamp," the successor of the nitrogen lamp. Formerly the bulbs of the tungsten lamps were evacuated as completely as possible, but it was subsequently found that if these lamps were filled with nitrogen at atmospheric pressure they could be run at a higher temperature and greater efficiency without too great evaporation of tungsten from the filaments. This is supposed to be due, in part, to the collision of the molecules of tungsten as they leave the surface of the filament with those of nitrogen gas, which drives many of them back to the filament. Since argon has a heavier molecule than nitrogen, and is completely inert, it has been substituted in these lamps, with a resulting further increase in efficiency.

Krypton, notwithstanding the minute proportions in the atmosphere, is possibly intimately connected with the phenomena of "northern lights," since the spectrum of these lights shows the lines of krypton with considerable prominence.

From a scientific viewpoint niton is the most unusual of these elements, s nce it possesses two characteristics which were absolutely unknown in 1895, namely, complete chemical inactivity, and a temporary existence due to atomic disintegration, the discovery of which has given rise to a new primary science, radioactivity. Niton has already been used, in aqueous solution, as a curative agent in radiotherapy. The nature of the changes involved could not be made clear without a somewhat extensive presentation of radioactive phenomena in general.

Although of comparatively little practical value in themselves, the discovery of these noble gases, closely associated as two of them are known to be with the story of radium and its congeners, has had an enormous influence upon our present concepts in physics and chemistry which is daily bearing fruit. What the future may bring is beyond the compass of our imaginations, but new ground has been broken, which has permitted us to delve a little deeper into the foundations of scientific knowledge. Old concepts have been confirmed and broadened (very few destroyed) while vast unsuspected stores of energy in common matter have been revealed, which only our ignorance of today prevents us from using for the purposes of life.

WORLD METEOROLOGY

WEATHER VARIATIONS OVER THE EARTH'S SURFACE GENERALLY CONNECTED AND THEIR RELATION TO FOOD SUPPLY AND TO BUSINESS CONDITIONS VERY MARKED

BY H. HELM CLAYTON

THE knowledge of the ways of the weather necessarily began at single isolated spots—a knowledge of what is going on in the sky above our back yards, so to say. We are now struggling to enlarge our knowledge of the weather to embrace the whole world.

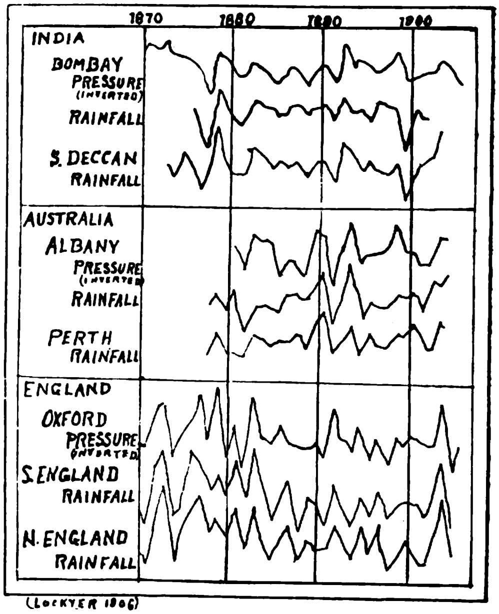
The earliest observations were of clouds sky-colors, signs in the sky and of the behavior of animals and of plants. This knowledge was embodied in sayings and rhymes, such, for example, as

> "A rainbow at night, shepherds' delight."

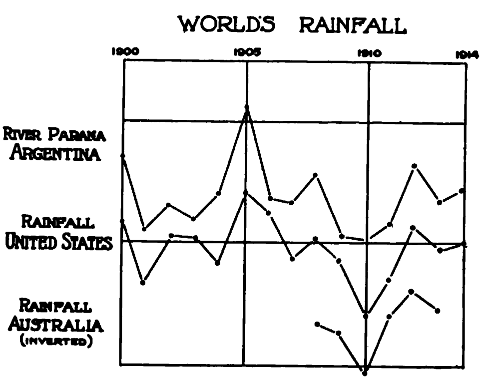
or

> "Evening gray and morning red,
> Will pour down rain on traveler's head.
> But evening red and morning gray
> Will set a traveler on his way."

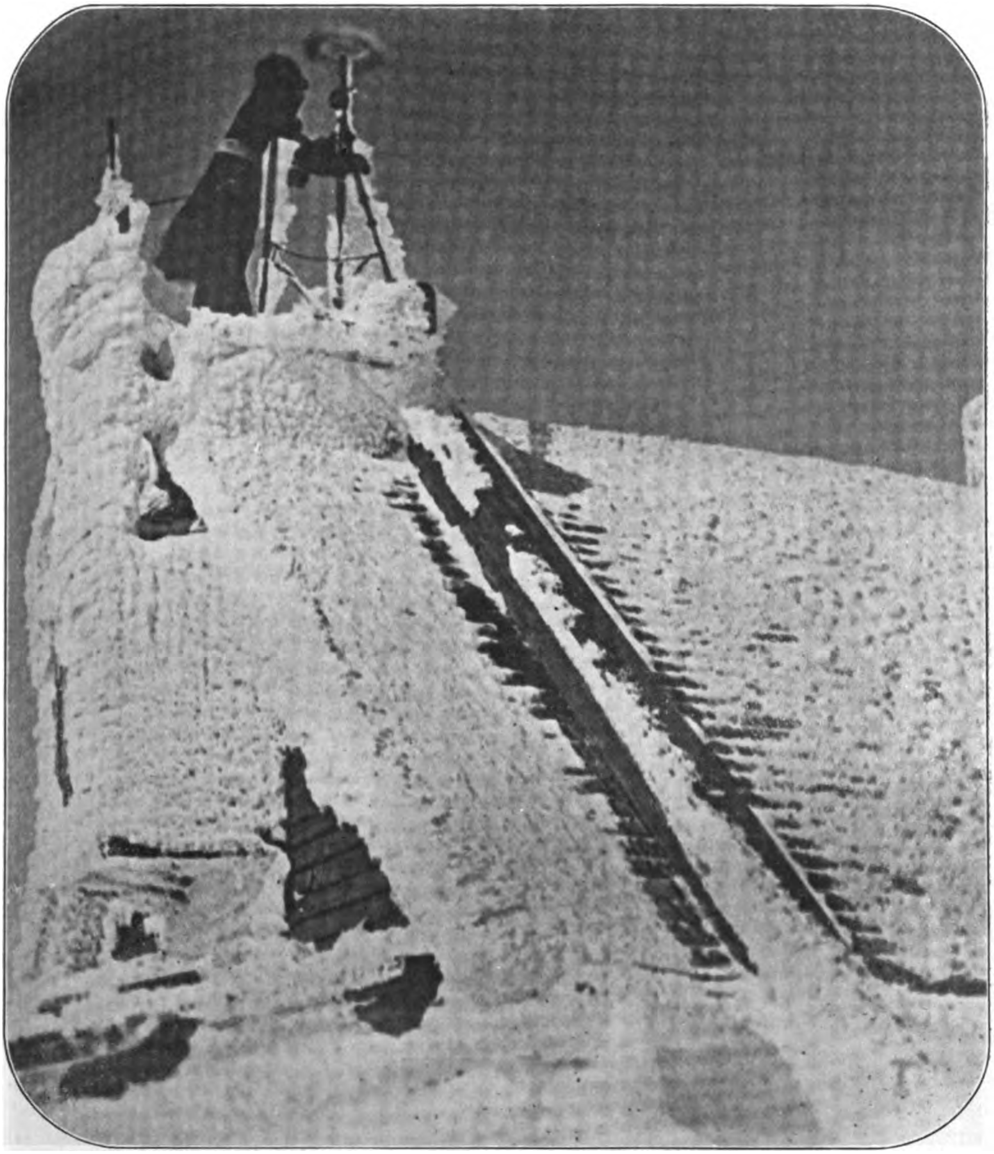
Each cloud received its special name, the highest clouds being called "cirrus." This species of clouds is formed of fine films of frozen vapor at heights of five or six miles in the air; then there is a class of clouds formed of filmy cloud sheets which received the name "cirro-stratus." Another type formed of small, rounded flakes, resembling the back of a mackerel, received the name of "cirro cumulus." The large heavy masses of clouds, which float in a summer sky and frequently form into thunder showers, received the name of "cumulus"; while the rain clouds received the name of "nimbus." To these names in recent years have been added other names and combinations such as alto-cumulus and alto-stratus, but a logical, scientific nomenclature is yet for the future.



Comparison of the relation between rainfall and pressure in different parts of India, Australia and England.



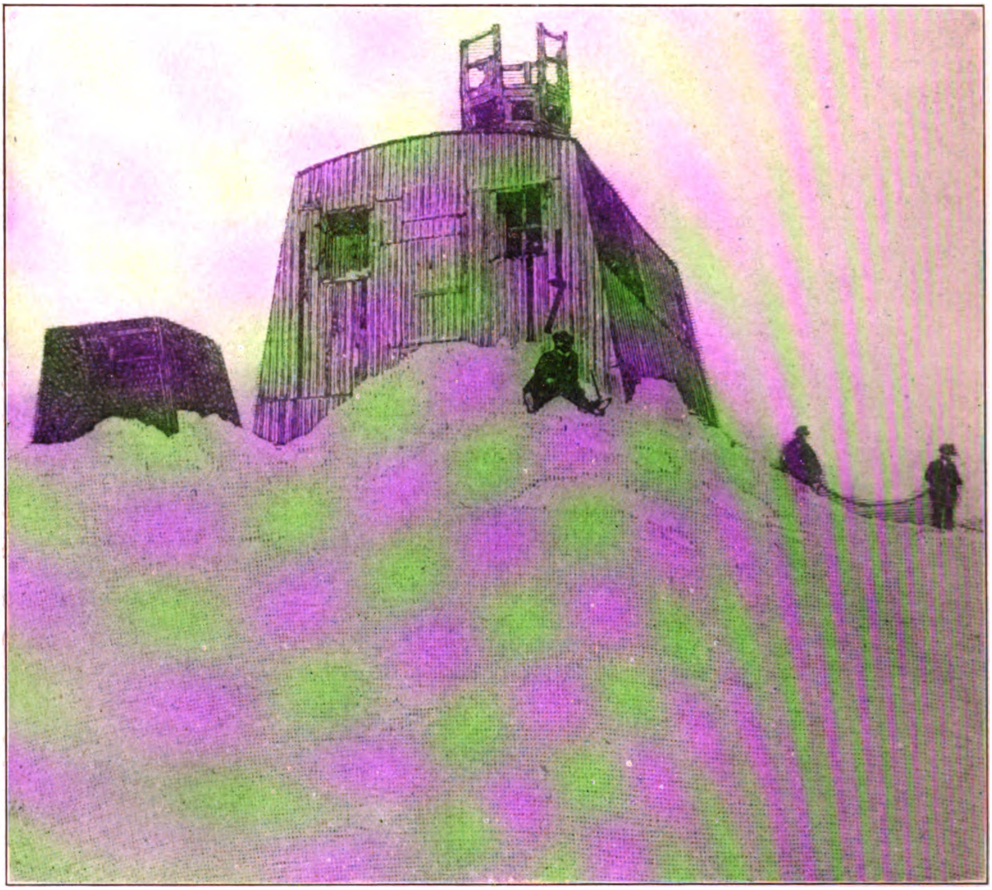
The early stage of weather study con-



Taking weather observations in winter on top of Mt. Washington.

sisted in observing clouds, their changes and developments, and even today the study of clouds is one of the most fascinating branches of meteorology. Next came the invention of instruments for measuring changes taking place in the air, such as thermometers, barometers and hygrometers. These instruments were observed by careful and interested students in various parts of the world, and slowly a body of scientific knowledge about the weather at isolated spots began to grow up.

It is uncertain who was the first to

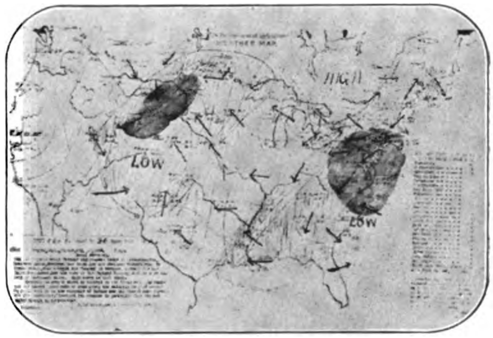


Observatory on top of Mt. Blanc, Switzerland.

discover the relations between weather changes at one spot and those at distant points, but Benjamin Franklin, in our country, is credited with being the first to observe that storms move from place to place. He was attempting to observe a lunar eclipse in Philadelphia in coöperation with astronomers in Boston but was prevented by clouds and rain from observing in Philadelphia. He later learned that observations had been obtained in Boston, and with his natural inquiring mind he also ascertained that the rain which prevented his observation occurred a few hours later in Boston. Subsequent inquiry developed the fact that this was the usual occurrence. Following Franklin in our country came Espy, Redfield, Loomis and Henry, who worked out a knowledge of the law of storms, showing that these were phenomena which extended over hundreds of miles of territory and, in the United States, generally progressed from West to East.

After this knowledge became general there began the organization of national weather services. The first of these was made in France, but the ones in America followed only a few years later, with the organization of a national weather service in the United States in 1871, and in Argentina in 1872. These weather services began the scientific gathering

Weather map of February 12, 1893, 8 p.m. Rainfall area shaded dark and cloud area shaded with lines.



Weather map of February 13, 1893, 8 a.m. Rain area shaded dark and cloud area shaded with lines.

of observations from points scattered all over the areas of the various countries, for the use of commerce and agriculture, and later undertook the making of weather forecasts for one day in advance. For the making of these forecasts telegrams are received at a central point from all the important stations in the country; charts are drawn up which become pictures of the various weather conditions over large areas and permit the central office to follow these changes from place to place and to anticipate their occurrence.

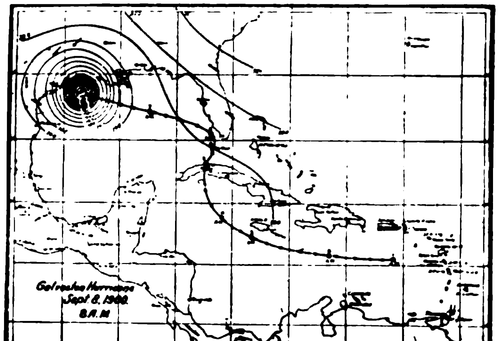
The most important of these changes in weather are the cold waves which sweep down from the polar regions preceded by storms of rain or snow, hurricanes, which sweep up from the tropics carrying destruction in their train, and the tornadoes, which devastate small areas particularly in the central part of the United States.

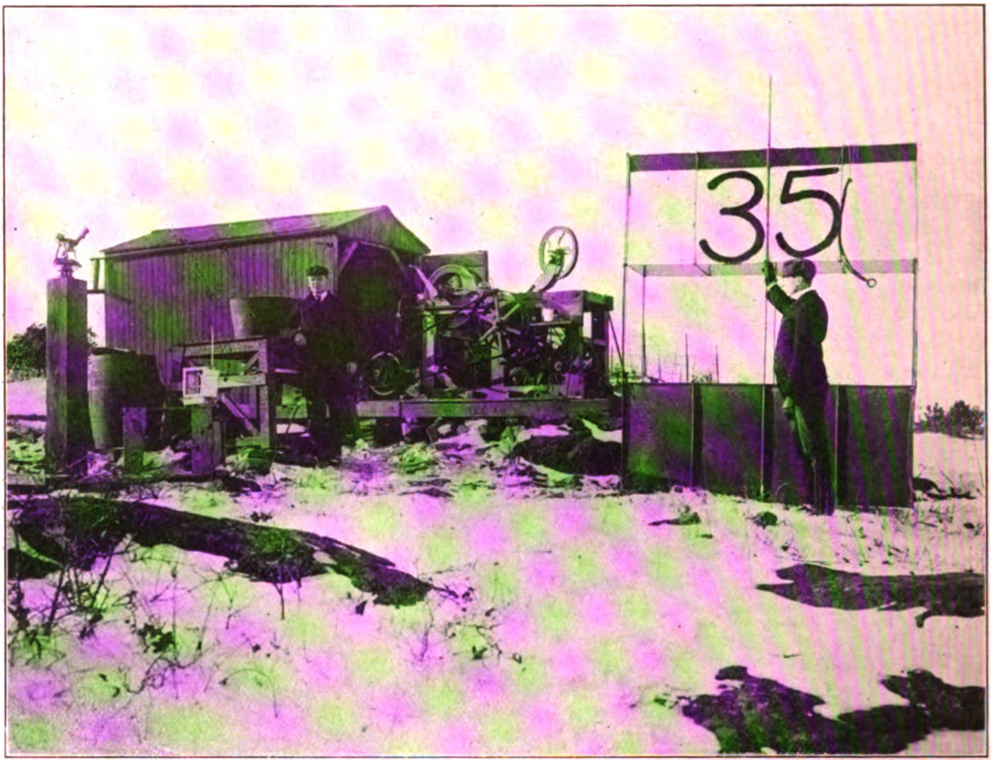
The West Indies hurricanes are storms of heavy rain and violent wind three or four hundred miles in diameter, which have their birth in the West Indies, move northwest and strike the American coast near the latitude of Florida or Texas, and then, changing to a northeasterly direction, pass off the coast of the United States into the Atlantic Ocean. The city of Galveston has twice been wrecked by hurricanes of this description, and in the past these hurricanes have been the terror of the ship captain. The worst of them leave in their train hundreds of wrecked vessels, and vivid tales of danger and hardships have been told by those who escaped the fury of some of these storms.

To better anticipate the coming of these storms a well organized observing service is now being instituted by the United States in the West Indies.

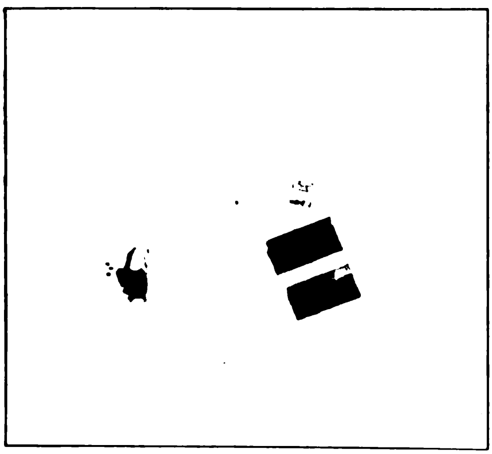
The tornado is equally violent, but over a much smaller area. Its path is usually only two or three hundred yards in diameter, but within that area there is usually complete destruction. Owing to their limited area and destructiveness, observations of these storms are almost impossible. There are only one or two instances on record where records from instruments have been obtained within their path.

The observations made for the various weather services of the world are confined



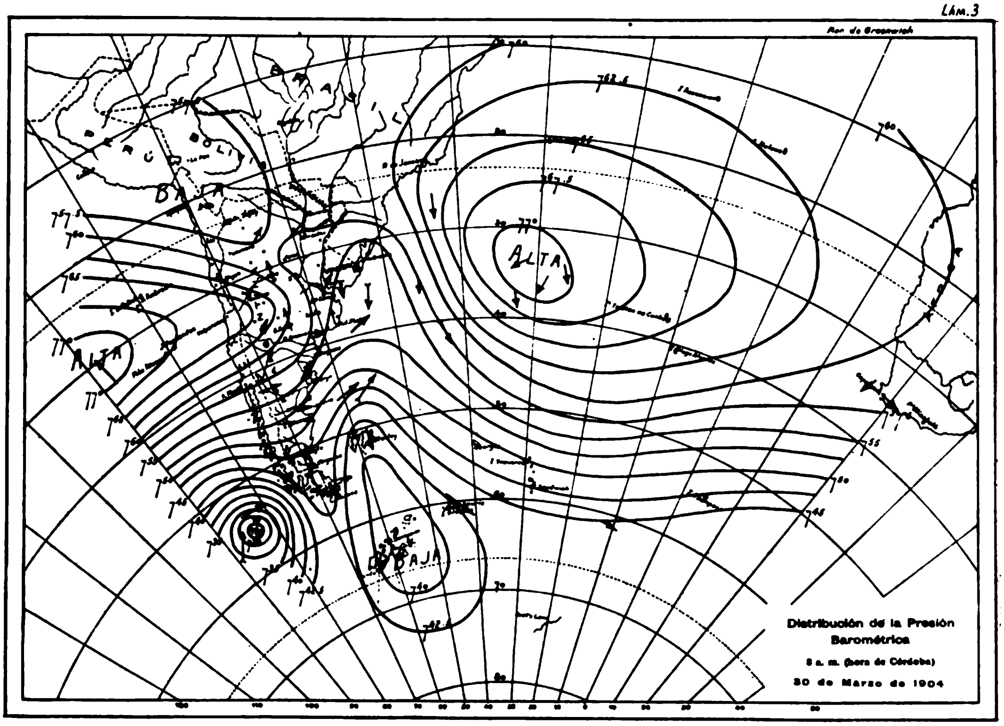


Kite, kite reel, recording instrument and other apparatus used in making observations in the upper air at Blue Hill.

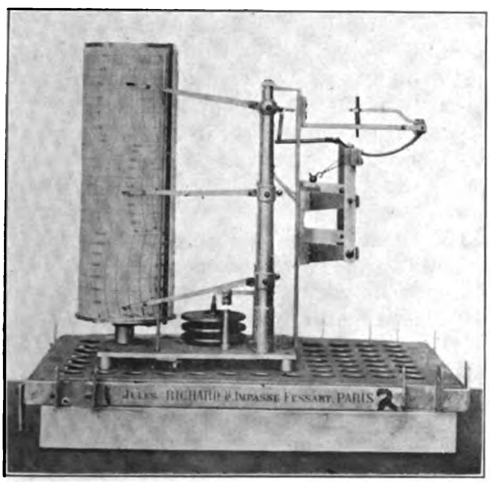


Instrument elevated by kites at Blue Hill.

to the land areas of the best organized governments, and there remain vast tracks of ocean and of land in which there are at present no organized sets of weather observations. To obtain additional data observations are taken over the ocean tracks by the regular steamers, and occasional observations have been taken outside of the regular ways of ocean travel by steamers fitted out to make scientific observations. I spent four months on one of these steamers fitted out by Teisserenc de Bort and Lawrence Rotch, exploring the air currents above the ocean. Observations as a rule, made by weather services, are confined to the air near the ground, but to make progress in the knowledge of the world's weather it is necessary to know something of what is going on in the air at great heights. As a beginning in obtaining knowledge of these conditions, observations were



Daily map of the pressure and winds in the southern hemisphere March 30, 1904. Published by the Oficina Meteorologica Argentina.

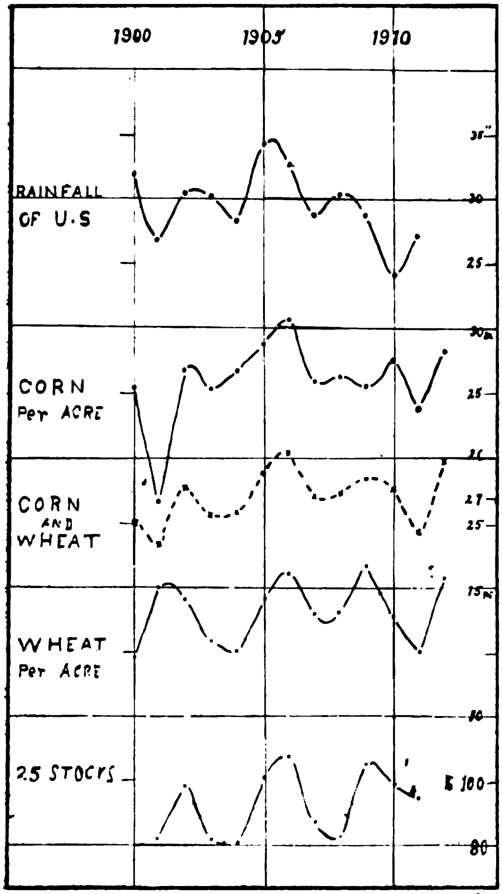


Recording parts of instrument lifted by kites.

undertaken on mountain summits, and stations have been established on the tops of many of the highest mountains in the world; but their results have been so complicated by the effects of the mountains themselves on the air, that the knowledge of the general law of the air has not been advanced greatly by the observations taken on these summits.

Another method of observing is in balloons, by which the observer is carried through the clouds to heights of four or five miles, but is prevented from going to greater heights owing to the decreasing density of the air. In the early attempts to observe the air in balloons several observers lost their lives by trying to rise to heights where life is impossible.

In recent years a safer method of observing and comparing weather conditions aloft has been made with instruments carried on kites. This method developed at Blue Hill was later adopted by the leading weather services. These in-



The annual rainfall in the United States, the total production of corn and wheat and the average price of securities showing the intimate relation between rainfall, crop production and business conditions.

struments have always been carried to heights of four or five miles in the air by kites, but the latest and best method of studying the conditions of the upper air was originated by Hermite in France and is by means of small balloons carrying recording instruments. These are left pilotless and free to follow their own course. They contain cards attached to the balloons giving the name and address of the person who launched them and offering a reward for their safe return. In this way a large part of the balloons and their records are recovered. These balloons have now reached a height of twenty miles in the air and have given the first real knowledge of what takes place at great heights in the earth's atmosphere.

The national weather services of the United States, France, Germany, England, Belgium and Argentina have taken an active interest in these researches.

The combined observation on mountains and with kites and balloons have shown that the air grows steadily colder as one rises above the earth's surface until the height of five to seven miles above the earth's surface is reached where the temperature, even in midsummer, is always far below zero. But above the height of seven miles the temperature rises again and continues to rise up to about twenty miles, the highest point yet reached by observing balloons. The place of lowest temperature in the air has been found highest near the equator and lowest in the polar regions, and it is for this reason that the lowest temperature of the air is found over the equator, because at a similar level in the colder region the temperature has begun to rise with increasing height above the ground.

These observations with balloons have also shown how rapidly the air moves from one region of the world to another.

At one time I made a voyage from St. Louis to New York in a balloon in about forty hours, using for this purpose the currents about a mile above the earth's surface. Other balloonists have gone even greater distances in a less time.

But perhaps the most interesting knowledge of the movements of the atmosphere as a whole have come from the outbursts of volcanoes, when great volumes of dust and smoke are thrown into the air and can be followed as they drift from point to point. One of the most remarkable of these volcanic outbursts was that of Krakatoa in 1883 when the dust was thrown to heights exceeding fifty miles. Krakatoa is near Java in the East Indies, and the dust from this volcano drifted within two weeks completely around the earth in the equatorial zone, moving at the rate of about seventy-

five miles an hour from east toward west. Within a few weeks the dust had spread northward and swept rapidly around the earth in the opposite direction, from west to east.

Air currents have also been followed from place to place over the earth's surface by means of dust elevated in dry regions by local whirlwinds. A body of dust raised in this manner was followed in 1901 from the Sahara Desert northward to north Germany and France in three days, and in 1903 a dust cloud was followed from eastern Africa out to the central Atlantic and thence northeastward to England, where it fell with the rain and gave an appearance of raining blood, a phenomena observed several times in English history, and interpreted as indicating dire disasters to follow. The dust storm of 1903 moved from the eastern coast of Africa to England within two days. Such observations as these show how great a rover is our atmosphere. The air which fans the tropics today may become a part of the air which we breathe in New York or Boston two days later, and the air which is driving in fierce storms across the Arctic ice today, two or three days later may be carrying a cold wave far southward toward the tropics.

Observations in various parts of the world have indicated that the winds of the world are arranged in belts, generally from some easterly direction near the earth's surface in the tropics and from some westerly direction near the surface in the temperate zones. The prevailing directions at great elevations remain yet more or less of an uncertainty, although we know that in the equatorial regions the general tendency is from the east at all heights up to about six or seven miles, while in the temperate regions the prevailing winds are from the west at all heights up to five or six miles. Above these heights the prevailing directions are as yet more or less uncertain.

Besides the waves of weather, which make up our day to day changes, there are now known to be larger, slower changes which form our periods of weather, as for example, periods of warmer or colder weather, or periods of wet and dry weather, which also drift from place to place in our atmosphere but more slowly than the changes which make the rapid day to day changes.

Again, it is also becoming known, by comparing the weather in widely separated parts of the earth, that there are large seasonal changes of weather, such as wet and dry seasons, or cold and hot seasons, in which the same kinds of variations take place in widely separated countries, while opposing variations take place in intermediate areas of the world. For example it is known that the weather conditions of India and Australia vary in an opposite sense to similar variations in Siberia and Argentina. It is also known that the rainfall of central South America and the rainfall of the United States follow very much the same general trend; while the rainfall of the tropical regions, as at Trinidad and North Africa, follow an opposite course, so that at times of excessive rain in central South America and in central North America are times of deficient rain or droughts in the West Indies and vice versa. It is thus becoming evident that the weather conditions over the entire earth's surface are more or less connected, and are probably dependent upon some factor outside of the earth itself. Just what that factor is remains yet to be determined with certainty, but the general belief is that it will be found associated with changes in the sun.

A considerable body of workers have been engaged in such researches, the most active of whom are Hildebrandsson, the Lockyers, Arctowski, Mossman, Exner and Craig.

These large weather changes, which make up seasonal variations play an exceedingly important part in human affairs. Rainfall in temperate regions determines the amount of crop production, and the subsequent food supply of the world. These variations in the food supply of the world are reflected in widespread variations in business conditions. The welfare of the railroad, of the ship-

ping industries and of commerce generally depends upon an abundant supply of food material, and when this is deficient, wide-spread business depression follows; so that variations in our business conditions follow a parallel variation in the rainfall of the world. Periods of excessive rainfall are invariably followed by periods of improved business conditions, and periods of deficient rainfall are followed by depressions in business, and in this way the variations in the rainfall influence the whole of human life.

HOW TO MAKE A FIREPLACE

Few fireplaces furnish a perfectly even combustion at all times; nearly all draw noticeably better on very cold days than on warm, murky days, and better in certain winds than in others. But it frequently happens, says the *Youth's Companion*, that the fireplace persists in sending smoke into the room. It then becomes a household torment that spoils tempers with its irritating smoke, and treacherously ruins the festive occasion it is supposed to serve. The visitor at old farmhouses is often surprised at the number of fireplaces that he finds sealed up.

The commonest defect in a fireplace is a lack of proper proportion between the area of the fireplace opening and the area or cross section of the inside of the flue or chimney. It should be as ten to one. When it is larger than that, more air is mixed with the heat, smoke, and gases, and the flue is unable to carry off the whole without artificial aid. If you discover that the mouth of your fireplace is more than ten times the area of the flue opening, you can reduce the former by placing a hood across the top of the mouth of the fireplace; but take care that the design of the hood is not out of harmony with the style and the lines of the fireplace.

The second common defect in fireplaces is the slanting throat. The mason who builds the throat of the fireplace with a slant (see AB in Fig. 1) is obviously thinking only of the column of hot air that comes from the fire, curves past the nose, B, and goes easily on and up. Thinking of the problem in this way, he sees no particular harm in making AB on a slant.

But in reality every household chimney must accommodate not merely one column of air, but two. Unless the fire has been hot for a long period and the draft is exceptionally strong, there will be a column of cold air coming down the chimney and striking at A. When AB is on a slant, this thin column of cold air slides down and meets the smoke and gases coming up from the fire. The result is to drive the smoke and gases—usually in little puffs—into the room.

The correct way to build the throat is to have AB flat, as shown in Fig. 2. Then the column of cold air rests on AB, and, curling up at the base, goes up in almost frictionless flight with the stream of hot air. The chimney then has a draft.

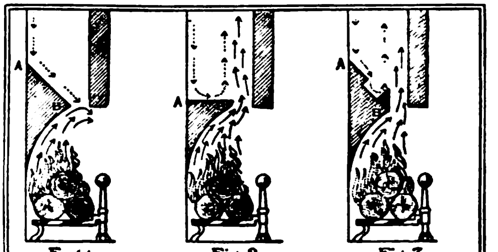


Fig. 1 Fig. 2 Fig. 3

An intelligent mason who discovers that his predecessor has built AB on a slant will knock out the row of brick at B, and then build a slight "retaining wall" of cement along the edge of the nose, three or four inches high (C in Fig. 3.). This "retaining wall" will keep the thin stream of cold air from sliding down into the fireplace and forcing smoke and gas into the room.

The two defects here described usually result in smoke, but there are fireplaces that, although they do not smoke, are "listless" and have poor drafts. They have to be fed with very dry wood, and tended with absurd care. Generally they can be much improved by extending the chimney ten or twelve feet in height. Sometimes—although not always—the additional draft can be obtained by placing on the chimney a revolving top.

Science Conspectus

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VOL. VI 1916 No. 2

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

VOL. VI 1916 NO. 2

A COMPARATIVE COLOR PHOTOMETER

ANNOUNCEMENT OF A NEW SYSTEM FOR THE STANDARDIZATION AND CHARTING OF COLORS AND ALSO FOR SCIENTIFIC COLOR SYNTHESIS

BY ARTHUR HOWLAND

THE Photometer is essentially a light tight box with a slide in the front having a small opening through the aperture of which the operator sees the absolute black of the interior. It contains a small high speed motor with a shaft arranged for clamping discs of paper or thin cardboard, which may be spun close behind the opening. The motor is screened from view by a second partition covered with black velvet, while a third screen back of the motor aids in absorbing any light rays which might otherwise find their way to the black velvet which covers the back of the box on the inside. By this method the background is so completely screened that the effect on looking into the opening is one of absolute black. In operation, the machine should be so set up, that light will enter only in the direction indicated by the arrow in Fig. 1, while the operator should stand directly in front of the box with his eye at the level of the opening and about fifteen feet away.

Sectors of all sizes from 0 to 100 per cent. similar to those shown in Fig. 2, are provided, with ends carefully coated with magnesium carbonate. Colored sectors of the same pattern are furnished in a few of the strongest colors obtainable.

With this outfit it is then possible to produce practically all known colors in every conceivable strength or luminosity. Mixing a white sector with the black of space gives an absolutely pure neutral gray of any desired luminosity as set by the size of the sector chosen, from a blacker black than any known pigment, to a purer white than has ever been produced in papers or pigments.

Mixing a colored sector with the black of space, gives the deeper shades of the same color or by using the white sectors in conjunction with the colored ones it is possible to make grayer or lighter tones of the same color. Again, by combining any two of the colors provided, in this same way it is a simple matter to produce any color desired within the limits set by the strength of the working colors used. To make the machine of practical value, it is necessary to discover very strong and pure colors.

Also it is quite essential that the colors be laid upon the sectors with an absolutely colorless medium as any oil or varnish vehicle would tend to discolor them to a marked degree.

After fully two years of research work such colors have been obtained and a method of applying them to fine white card stock has also been found. If at any time stronger colors are discovered

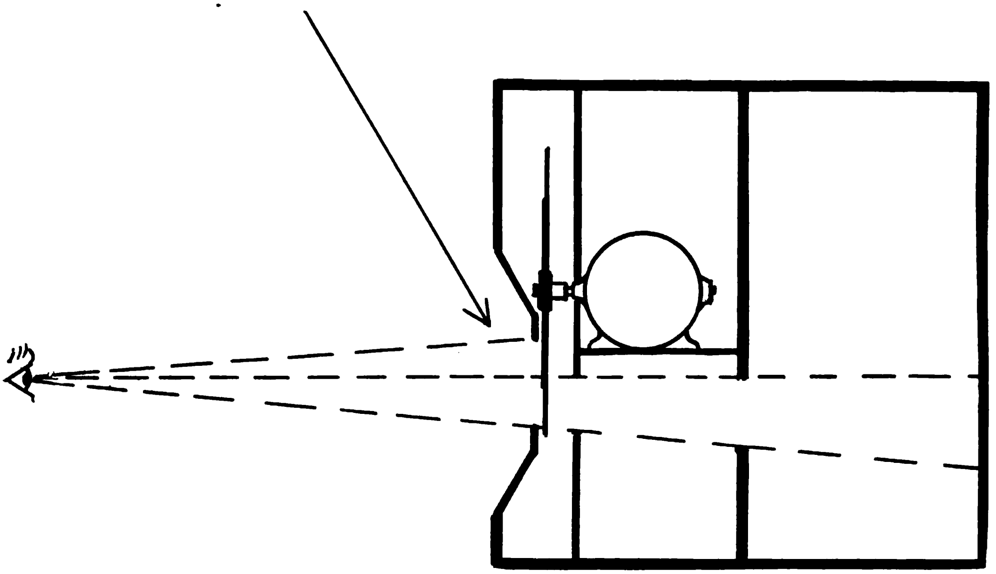


FIG. 1

they will simply increase the range of usefulness of the apparatus to within their own limits of strength.

Since all possible combinations of color may be made with this photometer, it is practically an easy matter to study the geometrical relationship of pigment colors with a view to charting them for commercial as well as educational purposes. Incidentally it has been found practical to place them with such accuracy that all combinations may be figured mathematically by using the three properties of color, hue, strength, luminosity.

THE CHART

The photometer is best used in conjunction with a chart which might well be called a "colorless" color chart (see Fig. 5) since there are absolutely no colors upon it, although every point of its entire surface may represent a different color or varying luminosities of the same color for any one spot.

It has long been known that every color has its opposite or "complementary" color, the combination of which will always give gray if spun in the proper proportions for exact neutralization.

By imagining each color as projected down upon a horizontal plane, we are enabled to use ratios of distances between them just as easily as if it were possible to take the measure of the actual distances in space. To illustrate,—if R (Fig. 3) is a certain red situated above a given plane and R′ is its projection upon that plane, and if G and G′ are respectively the position and the projection of a certain green, then if we wish to make a color Y intermediate between R and G, it is only necessary to spin the red and green discs together in the ratio of a′ parts of red to b′ parts of green to get the resultant color Y, which in this case is a dull yellow, since a′ is to b′ as a is to b. (In this case 3 to 5.) Suppose that our red has a luminosity of 27 per cent. of that of our standard white and that the green has a luminosity of 25 per cent., then to figure the resultant color, we use the following form,—

Area	*Luminosity*
R 37.5 per cent.	.10125
G 62.5 per cent.	.15625
	.25750

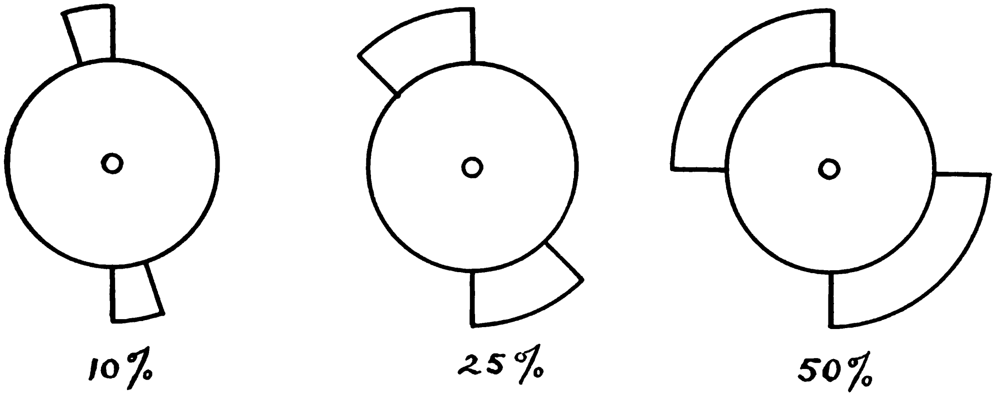


FIG. 2

This means that the resultant color, yellow, has a luminosity of 25.75 per cent. if made from the red and green above mentioned.

To produce this result the discs should be set as shown in Fig. 4.

All known colors may be placed about a neutral axis in space and will actually

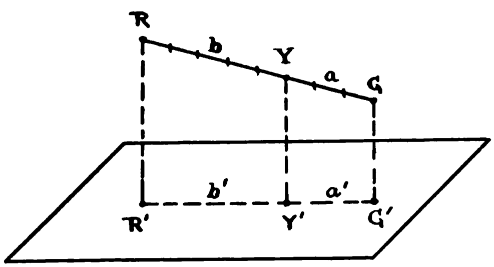


FIG. 3

respond with mathematically exact spinning ratios to the above method of procedure, provided they be properly located in their true positions according to their three properties of hue, strength and luminosity. By knowing the luminosity of the comparatively few working colors on the prepared discs and sectors, it is a very easy matter to figure out beforehand what color will result from any possible combination.

As there are endless combinations that can be made, it is also possible to figure combinations of other colors that will produce identically the same resultant and the color photometer will actually permit of making both at the same time. For an example,—take the above red and green in the proportions given to make a dull yellow. At the same time spin sectors of a strong yellow and white (with the black of space) on the same shaft with the red and green. (Fig. 6)

If the proportions of all of these colors used are taken from the horizontal chart as figured from the point where the lines between the components cross, it is an easy matter to figure both sets with such accuracy that the two combinations will match absolutely even though it may never have been done before.

If a strong yellow Y (Fig. 5) has a luminosity of 80 per cent. and the chart shows a ratio to the meeting point Y′ of say 18 per cent. of the yellow to 82

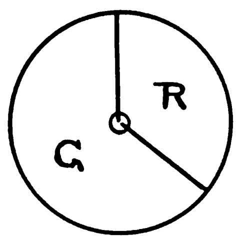


FIG. 4

per cent. of neutral gray N (black and white) the equation would stand as follows,—

$$\left.\begin{array}{ll} \text{R } 37.5\ \%\ldots & .10125 \\ \text{G } 62.5\ \%\ldots & .15625 \end{array}\right\} \text{ equals } \left\{\begin{array}{ll} \text{Y } 18\ \%\ldots & .1440 \\ \text{N } 82\ \%\ldots & .1135 \end{array}\right.$$

$$.25750 \qquad\qquad .2575$$

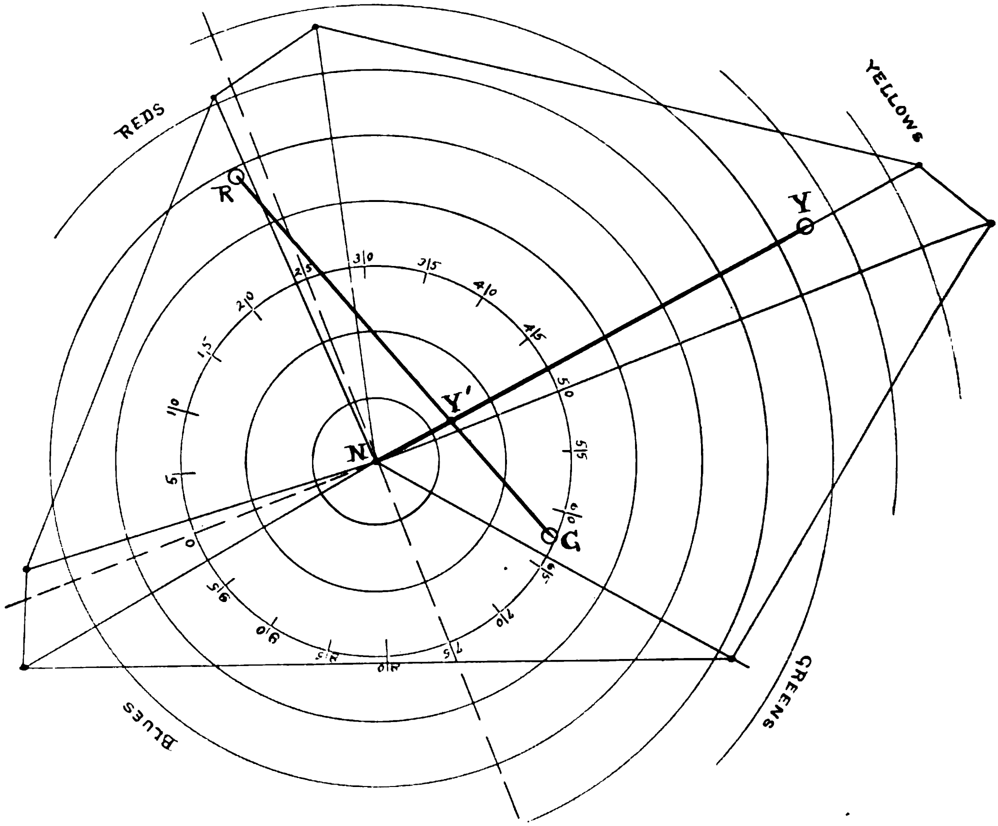


FIG. 5. The diagram represents the "plan view" of an imaginary color solid containing within its limits practically every known pigment color. The reader may be considered as above the drawing looking down upon the highest point of the solid at N, which point represents the upper or white end of the neutral axis containing all possible grays from absolute black to white. The lower or black end rests upon the plane of the paper.

Each of the limiting points of the diagram may be considered as the projection upon the plane, of various colors of great strength whose hues vary with their angular positions about N in exact accordance with the order of the spectrum through red, orange, yellow, green, blue, violet, and whose positions above the paper are fixed by their respective luminosities. Their relative strength is indicated by their distances from point N radially outward as 10, 20, 30, etc., and is determined by the concentric circles. Note that between the blues and the reds will be found all purples which are seen only in spectral colors when spectra overlap, the violet end of one with the red end of another.

While the placing of colors upon a chart in this manner is purely an imaginary one, it is nevertheless a fact that when properly placed they will respond with marvellous accuracy to exact laws of combination which this figure portrays. As soon as three color points have been determined, all other colors must then occupy fixed positions with respect to them.

Such colors will then obey the law of moments of forces with mathematical accuracy where the spinning area times the strength of one will always equal the spinning area times the strength of the other when opposed to each other as complements.

Moreover, when once a few strong colors have been properly located upon this chart, it is then possible to figure in color and solve problems mathematically, predicting the exact resultant color in all three of its properties of hue, strength and luminosity.

It will be noticed that the diagram is very nearly a true parallelogram, with the four colors red, yellow, green and purple-blue at the four corners. It should, then, be possible to produce all colors lying within these bounding points from a combination of these four with black and white. That such is actually the case, may be most beautifully demonstrated by the use of four such powerful working colors in the photometer described above.

Therefore the colors Y′ would be identical, since their position on the chart indicates their similarity of both hue and strength, and their luminosities are both .2575 as compared with the same standard.

These, of course, are very simple examples of what may be done with the machine in an educational way, but they lead to very remarkable possibilities with the refinements that are bound to come in the future.

It is always possible to retain a sample of the working colors in the dry powder form, which if kept in the dark in glass containers will not fade or change in

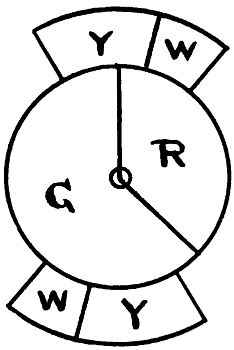


FIG. 6

any manner, so that they will always give a standard with which to work. If, then, a color is once matched to the standard *made from these working colors,* it is always possible to produce again the same standard from these working colors by taking some of the dry color which has been kept under proper conditions and placing it upon fresh discs and sectors. Manufacturers abroad could have working colors from the same pigments as standards and could reproduce any point upon the chart that might be indicated by American distributers. Such points could be indicated in several ways with great accuracy. While the actual percentage of each working color used in any given case might be easily cabled, a better way would be to designate each color wanted by three numbers indicating in order, the hue, the strength and the luminosity.

The three numbers, 23–49–31, for instance, stand for one color only, namely a red R (Fig. 5) whose hue is 23 per cent. of the angular distance from a point of lowest luminosity in the circle of spectral hues taken as 0, whose strength is represented by 49 units of distance out from the neutral point N, and whose luminosity is taken from comparison with the standard white used and is found to be 31 per cent.

An American manufacturer can match a piece of goods to his combination of sectors, locate it upon his own chart and cable the result to Paris or London, to any house that has a similar outfit with the certainty that under the same lighting conditions an absolute match will be obtained. Under ordinary conditions daylight from a north skylight will give satisfactory results but for very accurate matching it will be found that it is better to do the work by the aid of an incandescent lamp outfit with a screen and voltage regulator similar to some of those now upon the market for this very purpose.

Educationally, the photometer should be a wonderful aid to teachers and supervisors, who would be able to illustrate to their classes the exact composition of any given color, the relation of one color to any other, the harmony of different hues of the spectral circle, the complete separation of luminosity from hue or strength, and last, but not least, the fascinating process of producing new colors that have never been equalled in pigments. The machine is so sensitive that it will analyze even a black pigment, showing with great accuracy the percentage of red, or blue or green that is in it and making it possible to correct it to a completely neutral black.

There is probably no manufacturing process today, that does not use color in some form and it will undoubtedly be used even more generally in the future when some such standard will come into general use throughout the civilized world.

THE PROTOATOM OF A WORLD

A SUGGESTED COSMOGONY TO ACCOUNT FOR THE EVOLUTION OF A STELLAR SYSTEM WITHOUT THE NECESSITY OF MATTER BEING ORIGINALLY PRESENT

BY L. B. BUCHANAN

SEVERAL theories of celestial evolution have been elaborated by able minds and have received the appreciative consideration of the thinking public. The nebula hypothesis of La Place, with modifications introduced by later astronomers and the alternatives presented by Professor See and by Professor Lowell, are so well known as to need no description here.

All of these theories deal with the agglomeration of matter as such, by various probable methods, into stellar systems such as our own solar system and those which our galaxy reveals. Whether the origin be considered as gaseous, as meteoric dust, or as the result of near approach or collision of dark or visible stars, in all cases matter identical, or analogous to what we know as such, is presupposed to exist and be involved. Whatever action supposed to take place is accounted for on the theory of universal gravitation continuously acting.

Quite recently the writer, who is not an astronomer—in fact is only what might be called a commercial scientist—had the privilege of talking with one of the foremost astronomers of the world. The general subject of these remarks being touched upon, that eminent authority expressed himself to the effect that the astronomer does not ordinarily go into the constitution of matter in his investigation of such subjects.

The writer's courage in perambulating the infra-red precincts of cosmic evolution may therefore partake of the fearlessness of fools. Fully conscious of this, he is nevertheless about to embark on this adventurous course, with the hope that what he here sets forth, if patently unsound to the informed, may awaken a new line of thought in some readers.

Not necessarily as a substitute for the great theories mentioned in the first paragraph, but merely to be considered simultaneously therewith, is presented the following quasi-theory of cosmic evolution, which proposes the building of a stellar system, or of a galaxy, without of necessity any matter as such, originally present in the region of construction.

The theory presupposes the existence of the ether, the existence of one or more galaxies, the formation of atoms from electrons, the emanation and movement of electrons with velocities from zero to almost the velocity of light, the transmission of light by electromagnetic waves in the ether, the transmutation of so-called elements by radio disintegration, as evidenced terrestrially by uranium, radium, etc., the conservation of energy and continuity. Universal gravitation continuously acting is not presupposed; but gravitation is assumed as a universal property of all organized matter of the kinds with which we are familiar.

No new property of the so-called ether is prescribed. We can conceive of no limit to universal space, no beginning nor end to time and no beginning nor end to the universe, it presumably always was and always shall be.

Always there have been celestial bodies radiating electromagnetic waves and electrons in all directions, the waves always so far as we know with constant velocity, the electrons with all magnitudes of velocity up to that approaching the velocity of the waves themselves. Detached electrons are undoubtedly affected by electromagnetic waves, as for instance the repulsion of small particles by light waves, by electrical action upon each other, possibly by a resistance to motion

in the ether itself, possibly also by gravitation but scientists believe that any gravitational action of electrons is small compared with the electrical actions.

With the preceding in mind, consider in a large region remote from organized celestial systems a collection of electrons which have come from various radiating bodies and by virtue of various reactions and interactions have, relatively to each other and possibly absolutely, almost no motion, the probability is that the space density of these electrons will not be uniform, that by virtue of interference-wave residual effects, their distribution may be analogous to that of the sand on a vibrating plate after it has come to rest. Electrons of higher velocity may be continuously passing between them, changing their relative positions and likewise similar effect may result from electromagnetic waves from the remote stellar organisms, whence they themselves came. Let us consider that none of these electrons are in close enough proximity, or proper orbital relation, to constitute an atom of any matter which we know, but rather that the whole group, which let us imagine occupies several cubic light years of space, is at a particular instant one great protoatom, with little kinetic energy but with enormous potential energy, let us classify it as an ultra-mega-uranium, possessing enormous atomic weight, but owing to its loose organization and susceptibility to disturbance, having almost an infinite rate of decay. Imagine the decay to go on with the formation of smaller but still enormous protoatoms, each such successive decay occurring with increase of kinetic energy, radiations, loss of electrons, splitting off of groups, capable of becoming hydrogen, helium, etc., just as we observe in the case of terrestrial radium, recalling also the sustained temperature of radium above surroundings. Consider as a possibility the occasional happening of a configuration corresponding to that existing in known elements, that is, a resonator capable of responding to proper excitation, let the excitation be the repeated impetus received from some electromagnetic wave or combination of them coming from remote stars, we then by reason of the existence of an eternal element determine its persistence; like begetting like. Possibly some of the chance stable configurations resonate to electromagnetic overtones, in which case we have perhaps prescribed a condition of procreation of analogous rather than identical matter. So soon as we admit the formation of known matter, even if not before, we will gain the assistance of gravitation in the condensation of our proto-nebula. With increased kinetic energy and closer grouping of the electrons, we would expect the protoatom to disappear, always with relatively large amounts of hydrogen and helium as products, the occasional production of other known elements and possibly many mega-uraniums, matter far down the scale from the protoatom first considered, yet much more active as to rate of decay than any radio-active element we know.

Now what as to the temperature of this proto-nebula? We have seen that the evolution considered, means the giving out of energy in enormous quantity as radiation and expelled electrons; such action may well be capable of being seen from a remote distance, therefore the above question. First we must be sure we know what we mean by temperature; if we conceive of ether as incapable of possessing temperature, and for example, that in a given region of interstellar space there is one molecule of gas per cubic centimeter, no thermometer that we know would tell us anything about the temperature of that space, if we mean by temperature the kinetic energy of the gas in it. If on the other hand we mean the temperature of some discrete mass, as a thermometer or a meteoric stone which happens to be there, we must know the relative absorption and radiation rate of the mass, which will vary for every different shape, size and kind of mass. For present purposes we will take temperature to mean the heat intensity measured by the kinetic energy of the gas molecules and with our relatively widely scattered molecules in our sup-

posed proto-nebula we may have a high temperature but a small quantity of heat. Our nebula is hot, in that its mean molecular vibration velocity is high, but a ponderable body therein may be cold because there are not enough molecules or radiations striking it to make it take up heat faster than it radiates it, after a very slight rise. Any condensed nodule in the nebula might therefore act as a condenser for matter it came in contact with. Cold nodules might thereafter coalesce with such evolution of energy as to raise their temperature; indeed having generated our matter for the construction of a stellar organism from the electrons that came from those organisms which were before, we may choose any of the theories of condensation of the nebula which pleases us.

It should be remembered that the question of temperature may be of maximum importance in considering hot celestial organisms, or for that matter terrestrial matter heated to temperatures higher than those subject to past research, on account of the possibility of endothermic combinations at those temperatures and pressures, which would be impossible at temperatures with which we are workingly familiar.

In order to get a rough idea of what we have herein considered, the following approximate calculation has been made.

The nearest star is of the order of 4 light years away, consider the sun controls to ½ that distance, viz., 2 l. y., for simplicity's sake a cube of space whose side is 4 l. y. The volume of this space is 64 cu. l. y. or approximately 13×10^{39} cu. miles.

Consider the entire solar system to be equivalent to a sphere 1,000,000 miles in diameter, of density 1, a volume of approximately 5×10^{17} cu. miles weighing 2×10^{33} grams. Let this be imagined distributed in primeval state substantially uniformly throughout the 64 cu. l. y.; the amount of matter per cu. mile would then be 1.5×10^{-7} grams. A cubic mile is roughly 4×10^{15} c.c., therefore the matter per c.c. $= 4 \times 10^{-23}$ grams. Imagine for example that the matter is water vapor, of which at standard temperature and pressure 1 c.c. weighs 8×10^{-4} grams; we then have $\frac{4\times 10^{-23}}{8\times 10^{-4}} = .5\times 10^{-19}$ of the amount present in a standard c.c. Assuming a standard c.c. of gas to have 10^{19} molecules, there would be ½ molecule per c.c. average density. At 20,000 electrons per molecule there are 10,000 electrons per c.c. Assuming them placed equidistant they would average about ½ m.m. apart. The relation of this distance to their distance apart in ordinary matter is of the order of the relation of the distance between members of the solar system, to the distance of the farthest stars from the sun.

A comparatively short interstellar distance has been chosen for this example; we can conceive of the region occupied by the protoatom as being so remote from any star system as to include many hundred cubic light years instead of the paltry sixty four above considered, in which case the electron density could be very much less than what has been shown and yet the aggregate would be more than the entire solar system.

Consider our galaxy 40,000 l. y. in diameter and the space which it occupies included by a cube of that dimension, viz., 64×10^{12} cu. l. y.; on the basis of the same electron density assumed in the previous calculation, there would be matter enough to construct 10^{12} solar systems.

If we assume that our sun is an average star, we have provided for more by 5,000 fold than Roberts calculated on the basis of 4,000 stars per square degree, which he found in a rich portion of the Milky Way in Cassiopea, assuming that density to hold throughout the sphere, and more by far even than the same sort of calculation derives based on the Omega Centauri Cluster. This would certainly allow for enough dark stars to satisfy those who believe they greatly outnumber the visible ones and perhaps for enough to explain the velocities of 1830 Groombridge, Arcturus and Mu Cassiopea, which Professor Newcomb found anomalous, considering only visible stars.

Recent computations have arrived at

10^8 as the number of stars visible in our largest telescopes and from the fact that successively larger telescopes have not disclosed proportionally more stars, it is believed to be a reasonable approximation to the total number of visible stars. If we allow tenfold that number, viz., 10^9; the original electron density of our calculation is 1,000 times too great, so under the previous assumption that our sun is an average star, we could account for the entire galaxy with an original density of 4×10^{-26} grams per c.c. Strangely enough this would be just about the density of matter which Professor Schiaparelli calculated would completely intercept all light within the distance of the visible limits of our galaxy.

While this discussion has been confined to the generation of a stellar organism, there is nothing to preclude consideration of a similar action taking place in a smaller way within our sun's domain, in which case we must look to the comets as the little descendants of protoatoms formed from stalled electrons, within gravitational reach of the solar system.

A highly speculative attempt to build a world from mere electrons has here been made; if, as some of our leading scientists have thought, electrons are merely vortices in the ether, our world has been built from ether, not spontaneously but in a measure like ourselves, offshoots of those which were before. Thus the ovum of stellar life is the electron, a carrier of energy which changes from kinetic to potential and *vice versa*, is bartered and borrowed, but is never lost so long as continuity is assumed; the milt that starts the life may be the electromagnetic waves from the remote parent bodies.

Far beyond the infra red of the spectrum may be the line autographs of protoatoms whose vibrations are so slow and feeble that though their wave length is enormous compared with the longest Hertzian waves we know, the amplitude is so small that detection by any resonator of the high periods we are constrained to use is impossible. The protoatom thus may be beyond our senses, but some of the intermediary line of descent toward atoms of our acquaintance may be disclosed to future searchers for the truth Possibly the summational waves resulting from combinations and recombinations of the long waves above conceived may come into our sense scale, provided we can find the means to sufficiently keen our senses to the necessary observation; the Rosetta stone which shall make sensible that which is beyond direct impression.

Referring back to the subject of gravitation. Let it be said that biased by our experience which is consistent and identical, we always think of inertial mass and gravitational mass as one and the same, a little consideration will show that this is not necessarily true. If there was a coherent substance which was repelled by the earth and by all substances we now know, or if it were neither attracted nor repelled, we have no difficulty in imagining it to possess inertial mass, although in one case there would be negative, and in the other, no gravitational mass. If there were any such permanent substance ever on the earth it has long since been repelled to a remote distance, so that our inability to find such is no proof of the impossibility of its existence.

Such a substance may be possible by proper arrangement of electrons under the right conditions, high temperature may be essential, perhaps such substances exist temporarily in the sun and stars but decay to matter of ordinary properties before they get away, owing to drop in temperature. Such substances may be present among our protoatoms, if so the effect of gravitation may not always be present at all points in the proto-nebula. Inertial mass has been found to increase with velocity, but no direct observation of corresponding increase of gravitational mass has been reported nor has the question of whether gravitation has a finite velocity of transmission been determined.

In considering cosmogony, it is essential to take as broad a view of possibilities as may be permitted to tellurimental intelligence; with a plea for, if not a practice of, this attitude the above crude effort is submitted.

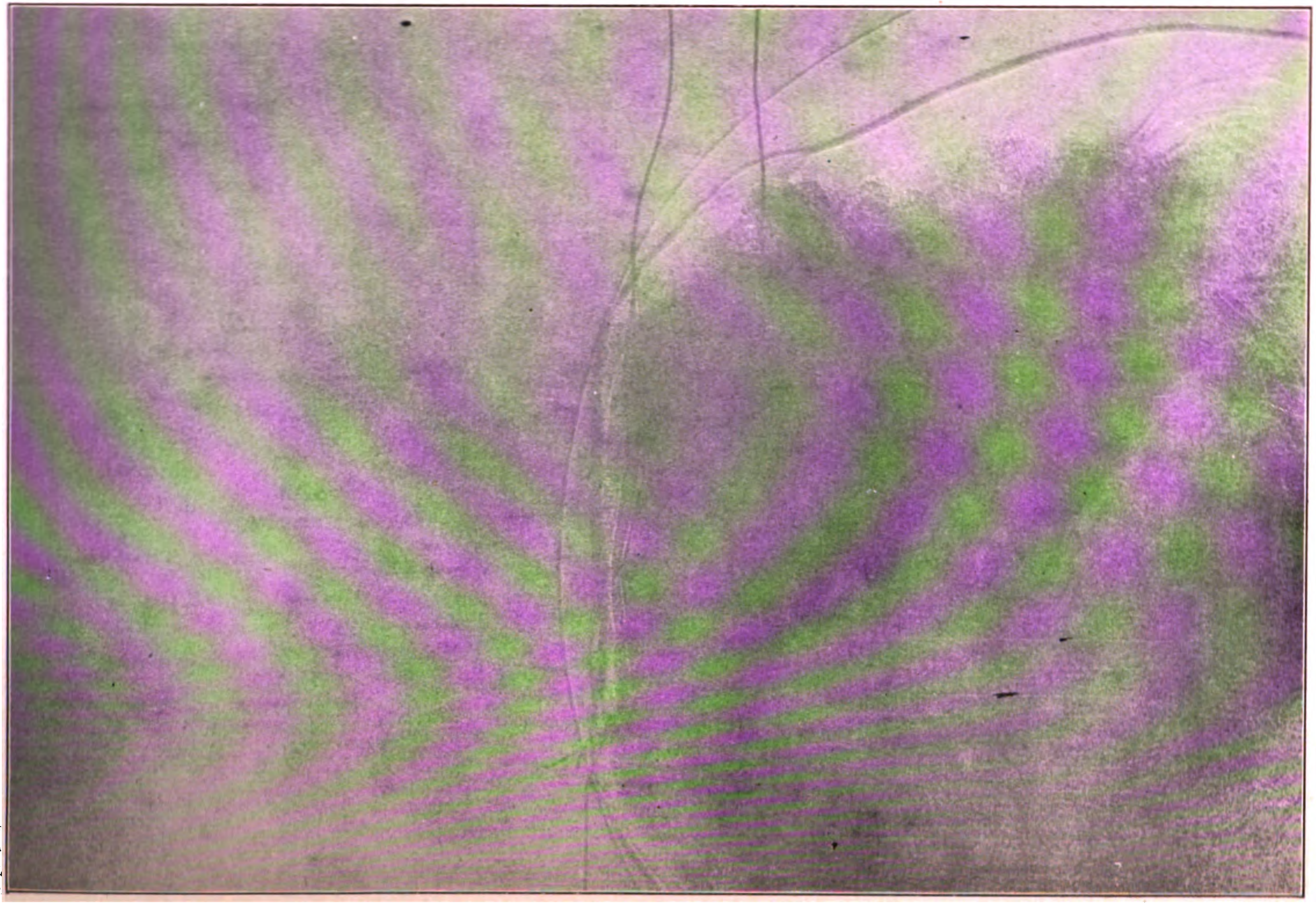


FIG. 1. PHOTO I. Without Silencer and directly at muzzle.

GUN REPORT NOISE

ACTION OF THE MAXIM SILENCER AND THE DIFFERENCE BETWEEN REPORT NOISE AND BULLET FLIGHT NOISE EXPLAINED

BY HIRAM PERCY MAXIM

WHEN a gun is discharged it is the common idea that there is a single noise heard, the report noise. That such is not the case, and that there are two entirely separate and distinct noises has been proved in a very interesting manner by the advent of the Maxim Silencer. The history of the research work which led up to this device is very instructive and well worth recording.

When the work was undertaken at the beginning, the object was to annul report noise so that concealment of position, partly attained by smokeless powder, would be completed. When the firing line became invisible, there was only left the report noise to indicate its position and also its strength, or number of guns.

To attain this object, it was thought only necessary to check the suddenness of the release of the high pressure powder gases into the atmosphere. This pressure, in the calibre 30 U. S. Service Springfield rifle, was approximately 10,000 pounds per square inch, when the base of the bullet emerged from the barrel muzzle. A device must be found which would present an unobstructed path for the bullet, but this path must not be available to the gas, at least easily.

The search for a path which would give a bullet an absolutely unimpaired passage, and yet would check gas at 10,000 pounds pressure per square inch, was a long one. For a year it persisted without results. Its successful ending came in a very interesting though extremely prosaic manner. The essential element was a hole which would be pervious to a rifle bullet, but impervious to high pressure gas. One morning, after taking a bath and pulling the plug in the tub drain hole, the water was given an accidental twist and the familiar little whirlpool was created. It attracted the eye and finally the mind, since there was a hole through which water was passing but slowly, notwithstanding the fact that the drain plug was removed. In a flash the analogy was apparent. It was obvious that centrifugal force prevented the water from passing through the hole rapidly. If the powder gases in a gun were given the same vigorous whirling action, they would also acquire centrifugal force, and, if their outlet hole were located at or approximately at the center, they would exit relatively gradually. They simply could not exit until they had slowed down at least a little. The search was ended.

A little gas whirling device was quickly made, and adjusted to the barrel of a rifle and the first shot fired was the first quiet rifle shot ever discharged from a high power rifle.

When shooting was done in several different places, it began to be apparent that the noise depended upon the place, at least when a high power rifle was used. It seemed to be impossible to eliminate a certain sharp "crack." The character of this crack was similar to a whiplash crack. It was entirely different from the more dull boom of the report. By accident it was found one day that this "crack" noise existed a long way down the range. A listener located at the 500-yard mark on a 1,000-yard range, detected the crack noise apparently overhead. This indicated immediately that it was connected with the bullet flight in some manner and was en-

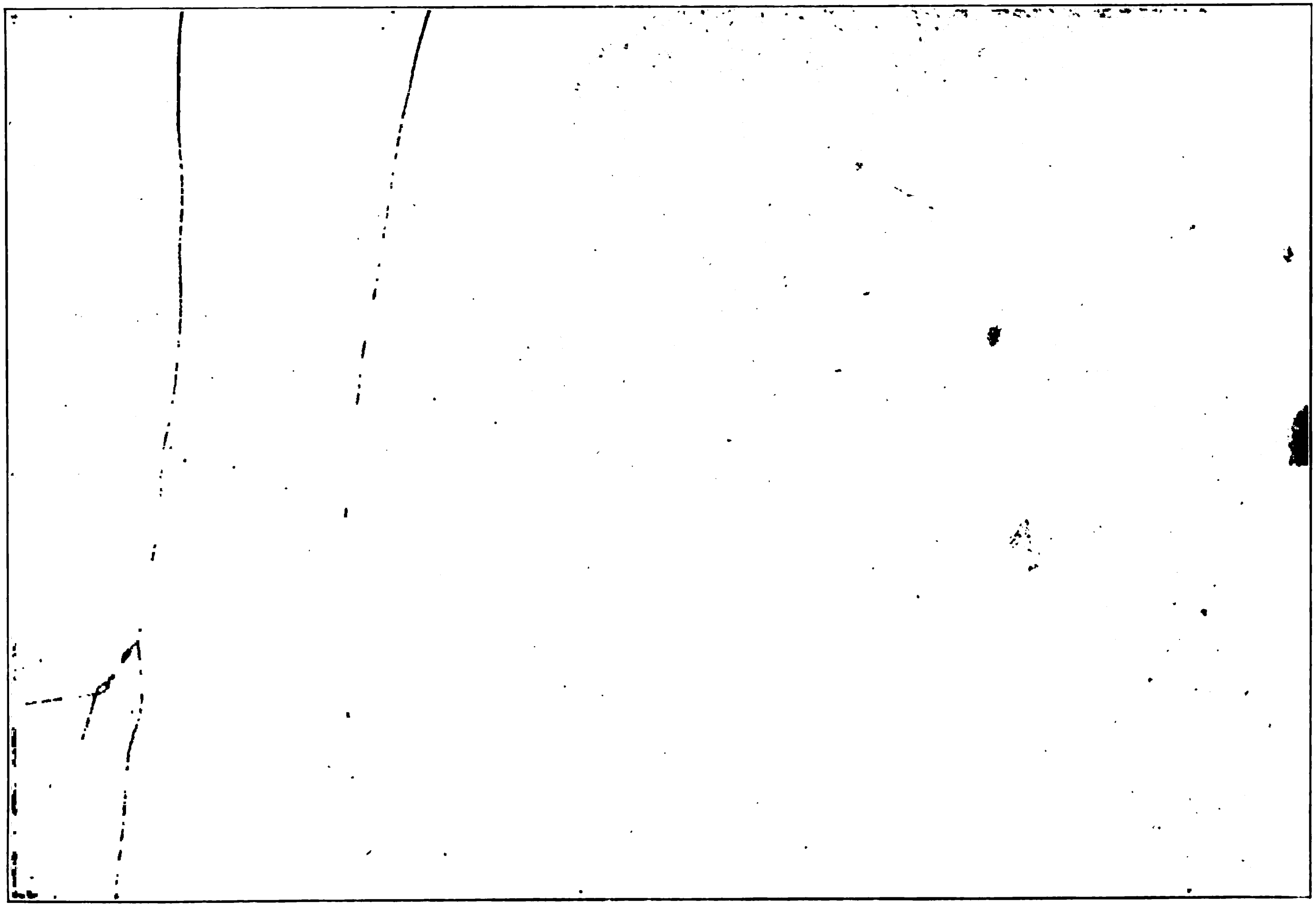


FIG. 2. PHOTO J Without Silencer, about 4″ from muzzle.

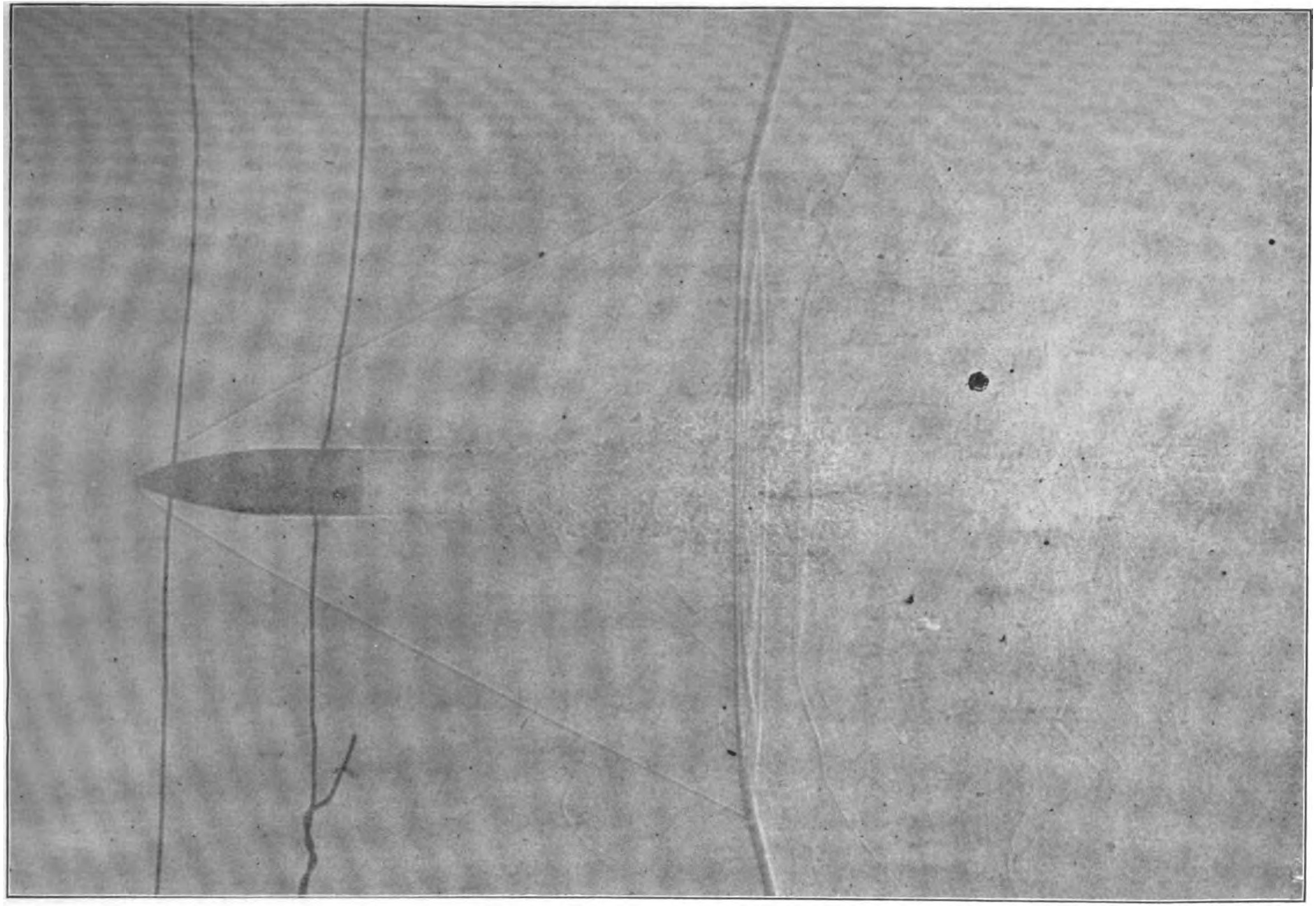


FIG. 3. PHOTO N. Without Silencer and about 8″ from muzzle. Note little grains burning smokeless powder, each creating small bow wave of its own.

tirely separate and apart from the report noise.

Tests were made to bring out additional facts, and some of these are instructive. It was suspected that the bullet flight created a bow wave, creating a little zone of compressed air which moved out from the trajectory, and that this wave was heard by reflection. The person shooting the gun always heard a different noise from the person located at a distant point down the range. A terrain was selected on the extensive meadows on the Connecticut River bank below Hartford, where a series of clumps of bushes and small trees existed. There were three separate clumps in front of which the bullet from a Springfield service rifle could be made to pass. When the gun was fired, the listener at the gun heard three separate sharp cracks, and a low rattle of many minor cracks. This pointed fairly conclusively to the fact that the bow wave was reflected back from each of these clumps and separate noises were heard from each because they were separated by enough distance to give a distinguishable interval.

It was then thought that firing down a railroad track which ran along the open meadow, and had telegraph poles at regular intervals, would give a good test. This was done and the result was a rapid succession of cracks, just as had been anticipated.

Then it occurred to the writer that if he could find a place to shoot where there would be no object from which reflection could occur, he ought to secure quiet shooting. It seemed a difficult condition to find until he bethought himself of getting up on a knoll away from trees and other objects and shooting straight up into the air. There would be no objects up in the air to reflect back the bow wave and if the theory were correct, such shooting should be almost entirely quiet. It was with much interest that a suitable place was searched out. One was finally found and the first firings were felt to be of great moment. The first shot told the story, for the only noise was the puff of gas from the Silencer which sounded very soft and low. There was absolutely no bullet flight sound heard. The bow wave went on and on and never returned.

The next thing was to locate the limits of this bullet flight noise. It evidently persisted in certain guns while in others it never occurred, while in still others it occasionally occurred. Bullets from various cartridges were fired and it very soon developed that when the bullet velocity reached the velocity of a sound wave, the crack became noticeable. When the bullet velocity fell below the velocity of sound, there was no crack noise. The velocity of sound then appeared to be the critical point above which the ordinary bullet could never be fired quietly. It developed that the .22 calibre smokeless cartridges, except in the case of the long, gave quiet shooting, because their velocity was below 1,085 feet per second. The long cartridge appeared in some cases to be above this velocity though not always. There was evidently un-uniformity. The long rifle cartridge was always beautifully quiet, as was of course also the short cartridge. The 22 W. R. F. cartridge, which is a special high power, seemed to be just on the critical line. For example, in a box of fifty cartridges, about half would shoot without bullet flight noise, whereas the other half would make a loud crack. With all the larger calibre regular cartridges, bullet flight noise occurred. By using special loads, they all gave quiet shooting. In some cases very heavy bullets were used and the striking energy maintained in spite of the lower velocity. The reduced velocity of course reduced the distance at which accurate shooting could be accomplished. Two hundred yards always was possible, however, with bullet velocity of 1,000 feet per second, which is well inside of the critical point.

Before the question was considered settled, it was thought necessary to make various shaped bullets. Some were made of approximately perfect stream line shape. Others were made with a central hole all the way through the bullet. A copper gas check was used over the base when firing, and this fell off as soon as a

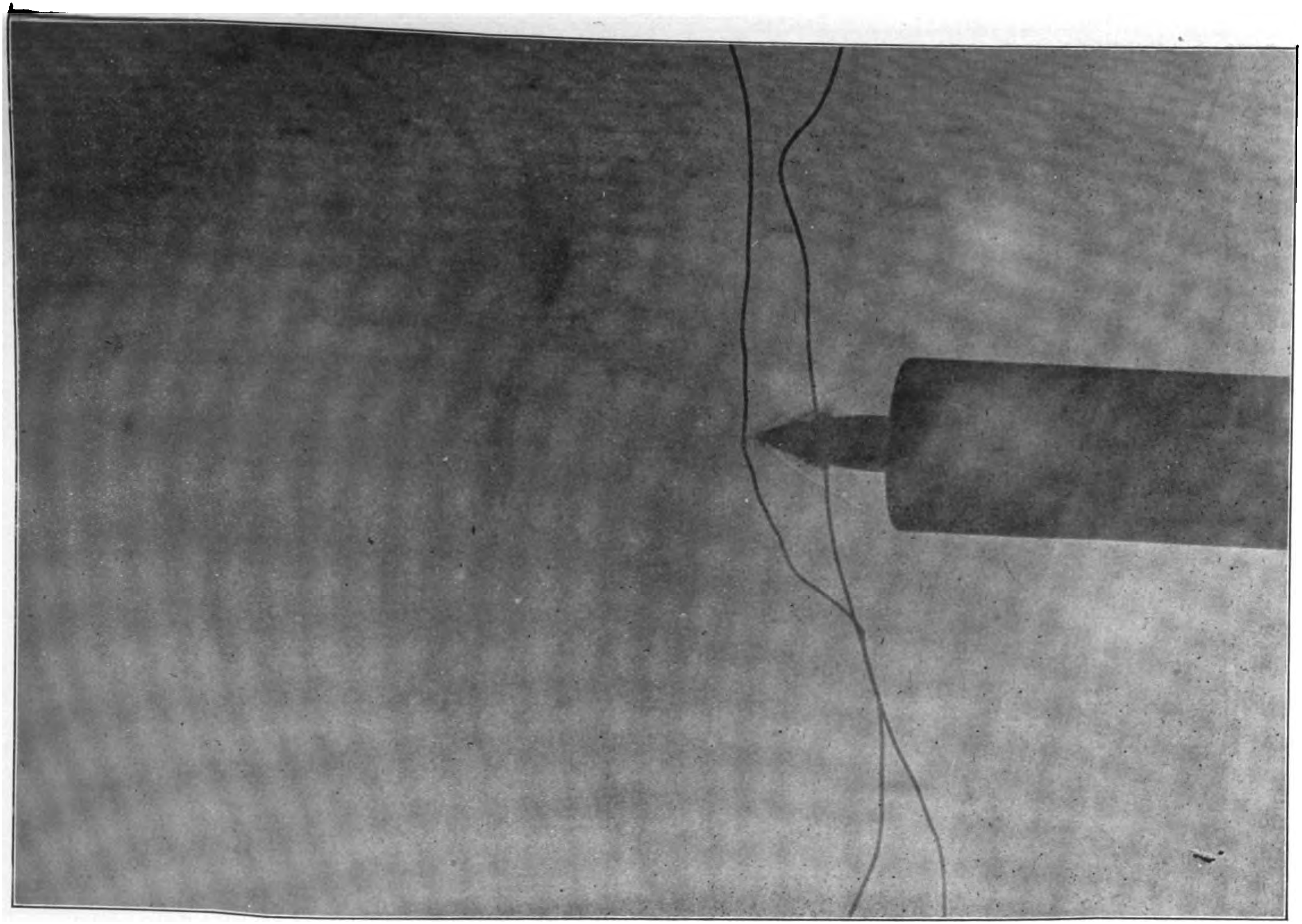


FIG. 4. PHOTO A. With Silencer, and directly at muzzle.

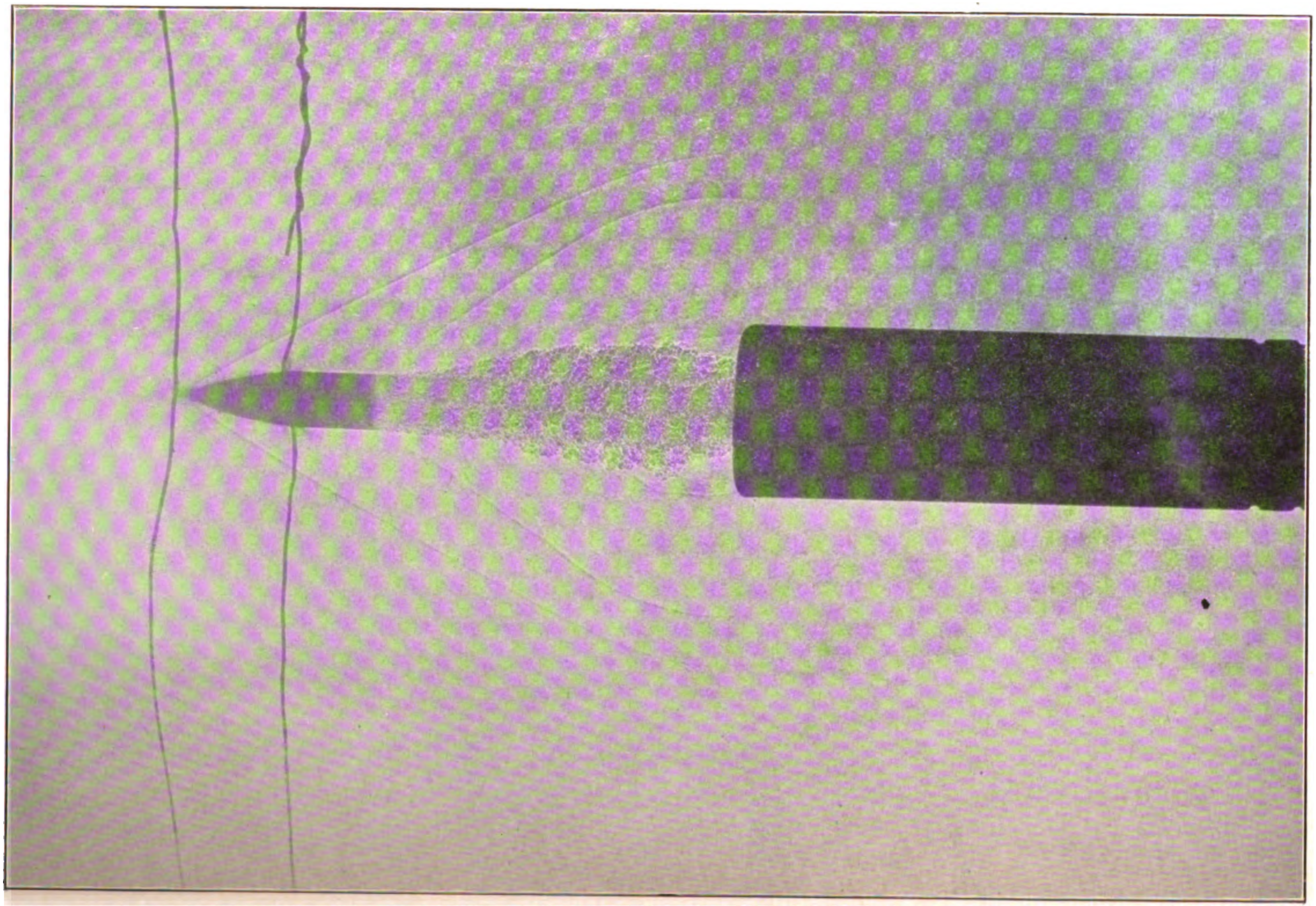


FIG. 5. PHOTO B. With Silencer, about 2" from muzzle. Silencer is 1" diam., bullet is ".300 diam.

bullet left the gun barrel. There never was a single piece of evidence upon which to hang a theory that the noise was in the slightest degree altered.

Then came the desire to actually see this peculiar manifestation, and, incidentally, to conclusively prove the Silencer. It was always a bit difficult to prove to the ordinary mind that the noise heard when shooting a rifle equipped with a Silencer was made out in the air beyond the Silencer, and that the latter should not be held accountable.

The United States Navy, through their Ordnance Department, produced the best photographs which have been taken. These were made by mounting the gun in a dark room and setting up the camera with an open shutter along the line of bullet flight. Two wires leading from an electric condenser were dropped down directly beside the trajectory so that the bullet would short circuit these wires when it passed, and create a spark, the duration of which was of radio frequency, possibly something approximately one five hundred thousandths of a second. This almost infinitely short exposure gave a clear photograph of the bullet and the variation in density of the air in the bow wave caused a variation in the refraction of the light, causing less light to fall where the pressure was high and more light where the pressure was low. Beautiful pictures of the noises made when the gun is discharged were obtained. Some of these are shown herewith. A series were taken showing the noises when the service rifle without Silencer was fired and another series with the Silencer. In the former, the report noise is shown, the birth of the bullet flight noise, and the bullet itself. In the latter the entire absence of report noise is shown and the very high efficiency of the Silencer demonstrated.

Fig. 1. (Photo I) Represents the condition existing immediately following the emerging of the bullet at the muzzle of the Springfield rifle without Silencer. The two vertical wires are shown and the bullet is enveloped in the mass of powder gases, and cannot be seen. The first wave appears to be made from a rush of air out of the muzzle and the main report noise wave is shown just back of it, being the broad dark line, irregular in places.

Fig. 2. (Photo J) Represents conditions just a bit later. The bullet was emerged from a cloud of powder gases, and has just begun the creation of its bow wave. It is shown puncturing the main report noise which shows particularly strong in this picture. By looking carefully, the noise waves set up by flying particles of unburned smokeless powder can be seen.

Fig. 3. (Photo N) Represents conditions still later, and out beyond the disturbance of the blast of gas from the muzzle. The bullet flight bow wave has developed farther and the greater velocity of the bullet over the report noise wave is very well shown. It is not plain at this time why the main report wave should be divided at the rear of the bullet. This completes the series of photographs taken without Silencer.

Fig. 4. (Photo A) Represents the first picture with Silencer on the rifle. The bullet is shown emerging from the muzzle of the Silencer, the bow wave of bullet flight noise is shown and there is absolutely no sign of any report noise. Indeed there seems to be no disturbance created at all except the bow wave from the bullet.

Fig. 5. (Photo B) Represents the conditions just a bit later. The bow wave and also a stern wave from the bullet is shown, the discharge from the Silencer, but absolutely no report wave.

Fig. 6. (Photo E) Represents a still later period, the bow wave being distinctly shown, and the wake of the bullet. The stern wave has begun to disappear, for what reason it is not quite plain.

Fig. 7. (Photo F) Represents a still later time and the wake of the bullet is the principle point of interest. This seems to partake of a spiral motion. The bow wave and the remnants of the stern wave are shown but no report wave.

Having now shown the conditions existing at the muzzle of a firearm, equipped with a Maxim Silencer, and proving as conclusively as seems possible that the

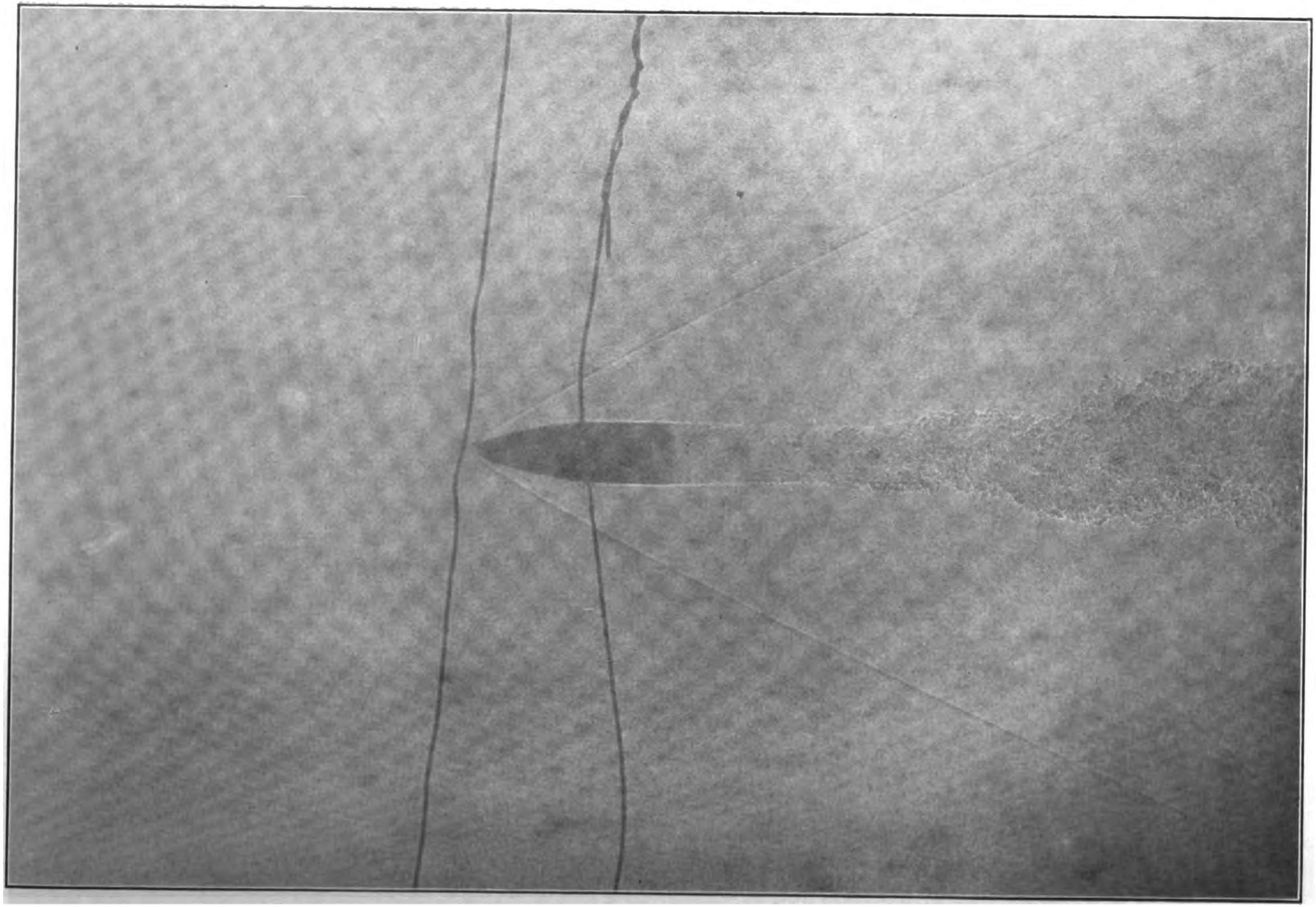


Fig. 6. Photo E. With Silencer, about 6″ from muzzle.

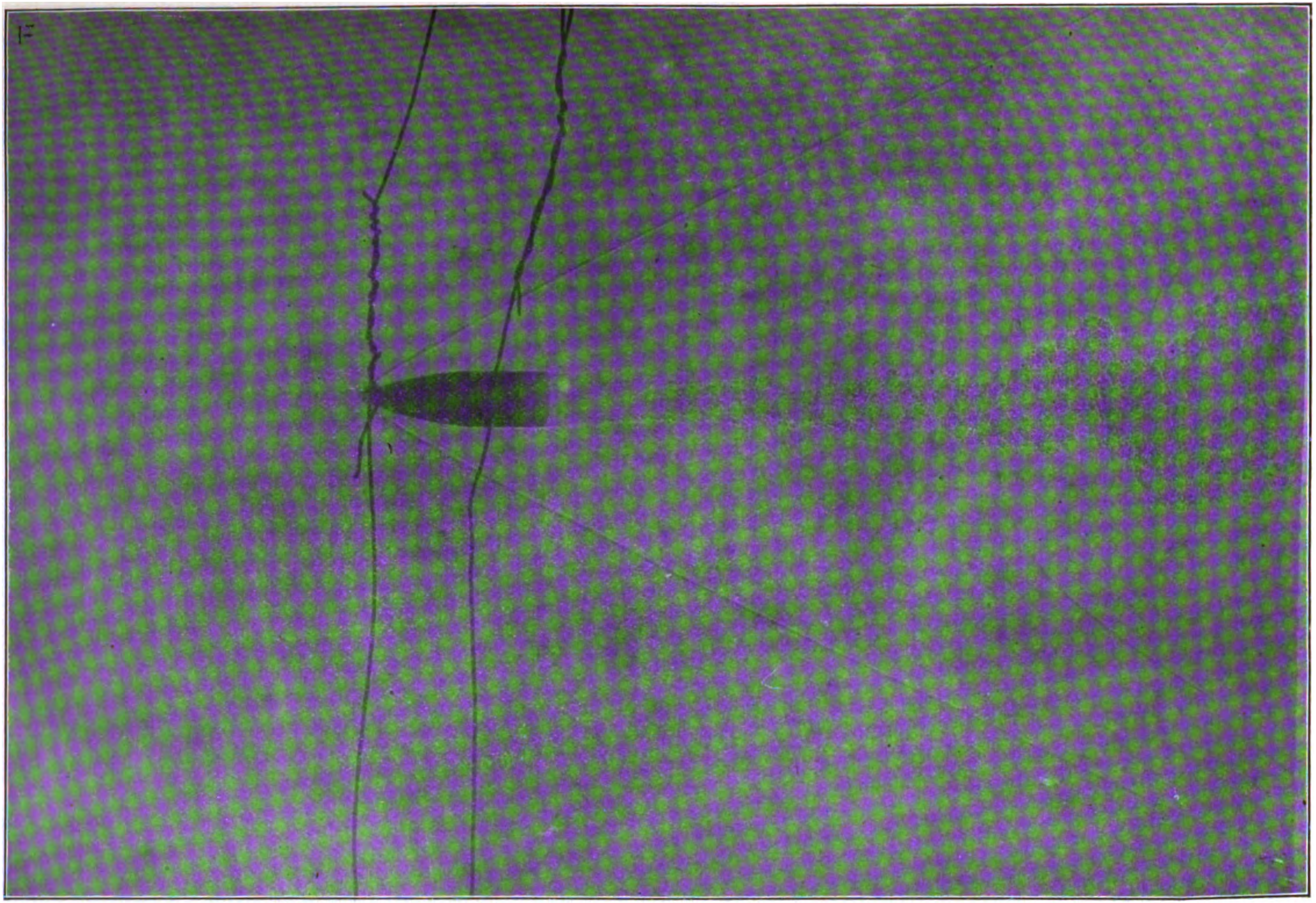


FIG. 7. PHOTO F. With Silencer, about 8″ from muzzle.

noise of the gun is eliminated and that the only noise remaining is the bullet flight, we may ask the practical results. These have been very carefully studied from every imaginable angle. Field tests, accuracy tests and tests at night have been conducted officially by War Departments with bodies of troops equipped with Silencers. Briefly summarized, these amount to the following:

1. The most important advantage on a shoulder rifle seems to be the diminution of sound on one's own firing line, which permits officers' commands to be heard during periods of the most rapid and concentrated fire. Without the Silencer the human voice cannot be heard.

2. The concealment of position of the firing line and the concealment of the number of guns comprising it. This is a natural advantage which might be imagined.

3. Improvement in marksmanship because of reducing the tendency to flinch. The elimination of the conclusion entirely and the reduction of the recoil by 50 per cent. makes the modern military rifle a much more gentle gun, and the rank and file in innumerable military tests always make higher scores than with the bare rifle.

4. Elimination of muzzle flash at night makes location of the shooter invisible. This is supposed to constitute an important military advantage.

The aspects of a quiet shooting firearm in the case of assassins is of interest. We have seen that we cannot secure quiet shooting unless we have bullet velocity below 1,085 feet per second. Except in 22 cal., this requires specially loaded cartridges for all calibres. Furthermore, the Silencer, being a gas check device purely and simply, and applicable only to the muzzle, the ordinary revolver cannot be silenced because of the joint between the cylinder and the barrel allowing the gas to escape if it is checked at the muzzle by the Silencer. Thus the assassin's favorite arm is unsilenceable, to coin a word.

In the case of the automatic pistol, it is almost an impossibility to attach the Silencer, and moreover the almost instantaneous opening of the breech permits a back blow and usually upsets the ejection of the empty shell enough to cause a jam. So, we cannot expect to see the automatic pistol silenced, as things stand today. The assassin will have to design a small arm with a breech mechanism constructed on the lines of a rifle if he is to take advantage of any silencing device. Such a weapon does not exist at the present time.

Thus, we have the story of one man's study of the noise that occurs at the muzzle of a firearm.

THE SCIENTIFIC WORK AT WOODS HOLE

GREAT VALUE OF THE UNUSUAL LABORATORY FACILITIES OF THE MARINE BIOLOGICAL LABORATORY TO THE STUDY OF THIS BRANCH OF SCIENCE

BY CAROLINE CHASE BIGELOW

THE scientific work carried on at Woods Hole has now become a factor of so great importance in all biological study that it is worth while to consider the scope at the present day in order to appreciate the growth from the simple pioneer work of forty odd years ago. In 1871, Spencer Fullerton Baird founded the government station; in 1888, a little group of men and women established a small private laboratory, selecting Woods Hole where the sea water is exceptionally pure, where the strong tide of the Hole keeps the water in a condition healthful for biological research, where no rivers decrease the salinity of the water, and where no large cities pollute the waters with sewage. From these early days of simplicity down to the present time, there exists a course of development in marine biological research which has touched many sciences, and contributed enormously to human knowledge. The extensive number of laboratory buildings, and the great number of scientists, many of world reputation, who visit Woods Hole each year, are strong evidences of the value of Woods Hole investigation at the present day.

Since the little Massachusetts seashore town first came to scientific notice the two institutions have been synonymous with the place. While absolutely separate in organization and maintenance, as well as somewhat diverse in purpose, the great subject of marine life cannot fail to link them in spirit. The Laboratory of the Bureau of Fisheries, maintained by the Department of Commerce, has the culture of fish for its aim, while the Marine Biological Laboratory, a private corporation, devotes its attention to abstract research and instruction; the one is commercial, practical; the other academic, "science for science's sake."

The Bureau of Fisheries has a small staff of permanent scientific men, and employs, in addition, each summer fifteen or twenty experienced investigators from various colleges. In the early days, these men thoroughly considered the conditions about Woods Hole, with the result that the rich marine life there is now more fully known than in any other region of similar extent on the Atlantic coast, temperatures, salinity, tides, currents, bottoms, fauna, etc., having been all most carefully studied. Then as the bureau turned to fish culture, primarily because of its decided commercial value, numberless problems presented themselves to the investigators. As the increase or decrease in the numbers of fishes about our coasts may be due to a great variety of causes, and may be controlled by an equally large number of factors, we find the government investigators studying the chemical conditions of waters in which the fish live, the environment, the foods, the plant life, the habits of each species, the nurture of the very young, the distribution, the diseases, the enemies. To quote a report of the Department of Commerce, referring to Woods Hole: "The information necessary as a basis for the conservation and improvement of the fisheries, therefore, covers a wide field in aquatic biology, physics and chemistry, and the scientific work of the bureau is governed by an appreciation of these requirements."

Recent or current inquiries include the study of oysters and clams, their food and oxygen requirements, the investiga-

tion of fishery by-products, water pollution as affecting economic animals, lack of resemblance between young and adult forms, as the flatfish. Furthermore, the work of the laboratory in winter is devoted almost entirely to the hatching of young fish to repopulate the coast waters, and in the year 1913–14 the station hatched and planted 182,000,000 cod, 373,000,000 flounder, and 2,500,000 mackerel. Besides this work which has a commercial character, the laboratory seeks also to foster pure science and welcomes, each year, qualified investigators who work on more abstract problems of marine biology, or men whose work along kindred lines may be advanced by the consideration of marine material. As an arrangement has existed from earliest times between the laboratory and various universities, whereby the latter may each appoint an investigator to a research table in return for money given towards building the laboratory, there are every year at the Fisheries, a few investigators and graduate students pursuing their lines of work apart from any problem suggested by the bureau. Connected with the laboratory are adequate craft for collecting material at various depths, fish traps, and an enclosed basin for the preserving of large living specimens. In years past, before the waters about Woods Hole were as carefully surveyed as now, excursions were made on well known boats such as the *Fish Hawk* or the *Albatross* for dredging and collecting in the Gulf Stream, the *Albatross* in 1883 making one of the early deep sea dredges on a trip from Woods Hole. Collecting trips are now principally confined to search for material needed by investigators.

The Marine Biological Laboratory, the neighbor of the Bureau of Fisheries, was founded in 1888, for the purpose, to quote from its own act of incorporation, "of establishing and maintaining a laboratory or station for scientific study and investigation, and a school for instruction in biology and natural history." In the early days, the character of the laboratory was of the very simplest; now, thanks to the generosity of Mr. Charles R. Crane, president of the corporation, the laboratory has recently acquired a large fireproof building, designed especially for research, and equipped with every known improvement. This gift has done much to raise the standard of the equipment to a level commensurable with the grade of work done within its walls. The laboratory has, first of all, a large and able group of investigators who pursue their own problems, and publish many of their results under the auspices of the organization. Second to them are a group of "beginning investigators," graduate students and the like who are pursuing their own problems under the experienced guidance of the older men. As nearly forty institutions now subscribe to research tables and rooms at the Marine Biological Laboratory, thus securing the privilege of appointing a man for summer work, the influence of the laboratory is becoming far reaching in the collegiate world. Lastly, the laboratory maintains a summer school (six weeks in time) offering courses in zoölogy, embryology, physiology, botany, and the philosophical aspects of biology and allied sciences. Members of the research staff, augmented by other gentlemen, give the instruction in these subjects.

The investigation covers, of course, all the field of marine biology, and the application which such work might have to any other science. The splendid new laboratory, with pure running water from the sea, chemical room, physiological room, balance room, a considerable outfit of physiological apparatus, a most adequate supply department for the collection of living material, all render the conditions admirable for serious work. Apart from the marine work, some investigators are pursuing other lines of biological research, choosing Woods Hole as a working place because of the laboratory facilities, and the inspiring influence of research enthusiasm. Such men as E. B. Wilson, T. H. Morgan, E. G. Conklin, Jaques Loeb, G. N. Calkins and H. E. Crampton have stamped their personality upon the staff of the laboratory. The instruction is planned largely for

Buildings of the Bureau of Fisheries at Woods Hole. From left to right: the laboratory, the power house, the residence. In the background may be seen the mess and the homestead of the Marine Biological Laboratory.

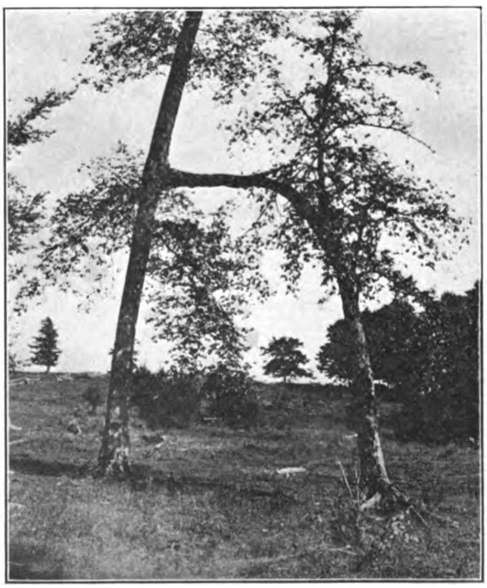
those having a professional interest in the subjects, supplementing college or university courses. Fundamental vital phenomena, shown to particular advantage in sea animals and plants, is considered, and stress laid especially upon living material. The opportunities to study development, or animal behavior as a living process in so wide a range of forms is unique, and the benefit of actually observing and of forming a conception of these phases cannot be overestimated. Encouragement is given to students interested in special lines of work, as preparatory to future research or to a profession. Lastly, the work in philosophy is offered to meet "a growing demand for a working out of the more general presuppositions, implications, and interpretations of the methods and results of biological investigation."

This, in brief, is the outline of the work carried on at Woods Hole. To appreciate the charm of the place, the lure of research, the fascination of living matter, one must participate, or at least be an intimate observer. Here the professor may work out his own absorbing problem amid peaceful surroundings, relieved from the cares of classes and administration, yet surrounded by equipment as fine as that of his own laboratory. Here the graduate student may start in on research, preparing for any scientific career, in an atmosphere where enthusiasm has gathered all the workers together. Here the undergraduate may add to his college curriculum a course

which can only be given in summer when living material is plentiful, and store up for himself, meanwhile, the wholesome vigor gained by a summer vacation in a simple seashore town. Looking back over the history of Woods Hole, the words of Mr. Crane, at the opening of the new laboratory, seem most pertinent: "We have come here to celebrate the wonderful spirit that is back of the Marine Biological Laboratory. It is very difficult to define that spirit, but I think we all know something of it, and something is also known all through the scientific world. Without that spirit, no amount of bricks and mortar and organization would be of great service, but with that spirit the laboratory has been able to accomplish a very great deal, with very simple means."

TWIN TREES

An unusual example of grafting is seen in two elms (*Ulmus americanus*) growing near Cortland in central New



York. They stand upon a bluff overlooking Brown's gorge and are far from any dwelling. The trees are twenty feet apart at their base and unite at a height of twenty-five feet above the ground. That the union of the trees is physiologic as well as superficial is shown by the enlargement of the combined trunk immediately beyond the point where they meet. The smaller tree is fourteen inches in diameter at its base, the larger eighteen inches, both normally decrease in diameter to the point of union, immediately above which the trunk enlarges to a diameter considerably greater than immediately beneath, from which it again tapers normally. This tree reaches a height of about seventy feet. The roots of the smaller tree are partially uprooted on the side farthest from the larger one and the uppermost of these roots have long been rotted away leaving mere stumps. This early uprooting, and hence probably also the grafting, was evidently the work of a wind storm, though it is a common belief of the countryside that the grafting was the work of the former Indian inhabitants.

H. W. S.

SOUTHERN HEMISPHERE COLDER

Dr. G. C. Simpson, the British meteorologist, believes that the southern hemisphere is much colder than the northern hemisphere, the reason being that while on the northern hemisphere there are large masses of land to take the sun's energy and give heat to the air, in the southern hemisphere there is much more ice, which is practically a perfect reflector, returning into space the solar energy falling upon it. Dr. Simpson thinks that five million square miles of the earth's surface in the southern hemisphere returns the heat of the sun, and this is one of the chief reasons for the difference in the temperature between the two hemispheres.

Owing to the high price of aluminum a California power company is substituting copper wire at an appreciable profit.

NATURE'S UNITY OF PHYSIOLOGICAL PLAN

ANIMALS are those organisms whose most fundamental characteristic is movement. They vary in size from microscopic forms to the whale, and in complexity from the one-celled protozoön, in which all bodily functions are performed by this one cell without organs, to the vertebrate whose body is composed of millions of cells arranged into many organs for the performance of the bodily functions. Throughout, however, this immense diversity of size and complexity there exists one unity of physiological plan. The simplest organism has the same fundamental bodily needs as the most complex and hence performs the same physiological functions with its far simpler mechanism. In the common necessities of digestion, respiration, etc., the protozoön is at one with all life up to man.

All animals must alike procure food, swallow and digest it; the digested portion must be carried to all parts of the body for its repair and upbuilding; at the same time the worn-out portions must be carried out of the body. All animals must move and breathe, and sense the presence of food or things objectionable.

These common needs and their expression in the same physiological functions may be indicated in a comparison between the comparatively highly developed snail and man, who crowns the evolving line of animal life. Both make the food fine before swallowing it so that it may be digested the more readily, the former by means of a file-like tongue, the radula, the latter by teeth. Digestion, or chemical disintegration of the food into a condition in which it may pass through the walls of the digestive canal into the blood vessels, is performed alike by both; this is done largely in the anterior portion of the digestive canal, the stomach, while the posterior part, the long intestine, gives opportunity for the blood vessels to absorb all good food, the undigested remnant passing out of the canal as solid waste. In both the mollusk and man, closed tubes, blood vessels, carry this food mingled with the blood to all parts of the body, and a heart helps to force it along more perfectly. As the blood gives up this food for the repair and upbuilding of the body it gathers up the broken down cells and other body waste, which it gives up to the kidneys through which it passes before reaching the heart; these glands throw it out of the body. Besides passing through the kidneys the blood similarly upon each circuit of the body passes through an organ where the gaseous requirements (oxygen) of the body may be procured and the gaseous waste (carbon dioxide) thrown out. This organ is called a gill when the oxygen is taken from the air enclosed between the molecules of water, and a lung when the oxygen is taken directly from the air. The gill in the mollusk is an outpocketing of the mantle, a thin fleshy fold surrounding the compact body and lining the shell. The blood pouring into the blood vessels lining these minute pockets is separated from the water by a thin moist membrane through which the waste gas, carbon dioxide, brought by the blood from all parts of the body, can easily pass by osmosis and the needed oxygen enter. In man the lung is an outpocketing of the throat, but since a moist membrane is necessary for the osmotic interchange of these gases the lungs become of necessity enclosed within the body; the air is taken into these much-divided outpocketings and finds all the surrounding walls penetrated by a network of blood vessels, through which the interchange readily takes place.

To control the exact performance of these complicated functions as well as to perform the complex movements necessitated by the desires of the organism, a multitude of nerves, like telegraph wires, extend to every part of the body. In the mollusk these are much more poorly centralized than in man. In the former the principal centers are a couple of enlargements, ganglia, in a nerve ring around the

throat; these are connected with a ganglia in the foot and with one in the digestive region of the body. The mollusk may thus be said to have a diffused brain.

In man the nervous system is well centralized, most messages being sent to the brain or to its posterior prolongation, the spinal cord. In both organisms, however, despite the vastly differing complexity of the mechanism, the fundamental need of movement is performed by muscles controlled by nerves and the fundamental processes of digestion, respiration, etc., are performed by organs of similar fundamental plan, controlled in each case by sets of nerves and ganglia.

Man possesses no more sense organs than do most mollusks though here again there is an immeasurable difference in complexity and power of perception.

Such a comparison enforces the realization on the one hand of the oneness of all beings in nature, and on the other of the mighty force of evolution in bringing the complex from the simple, the highly developed from the primitive.

HERVEY W. SHIMER.

Above is a much enlarged photograph of two phonograph needles, a new one and one that has been used to play one Wagner record. The phonograph companies are making extensive research to find a material from which needles can be made that will not require frequent renewals.

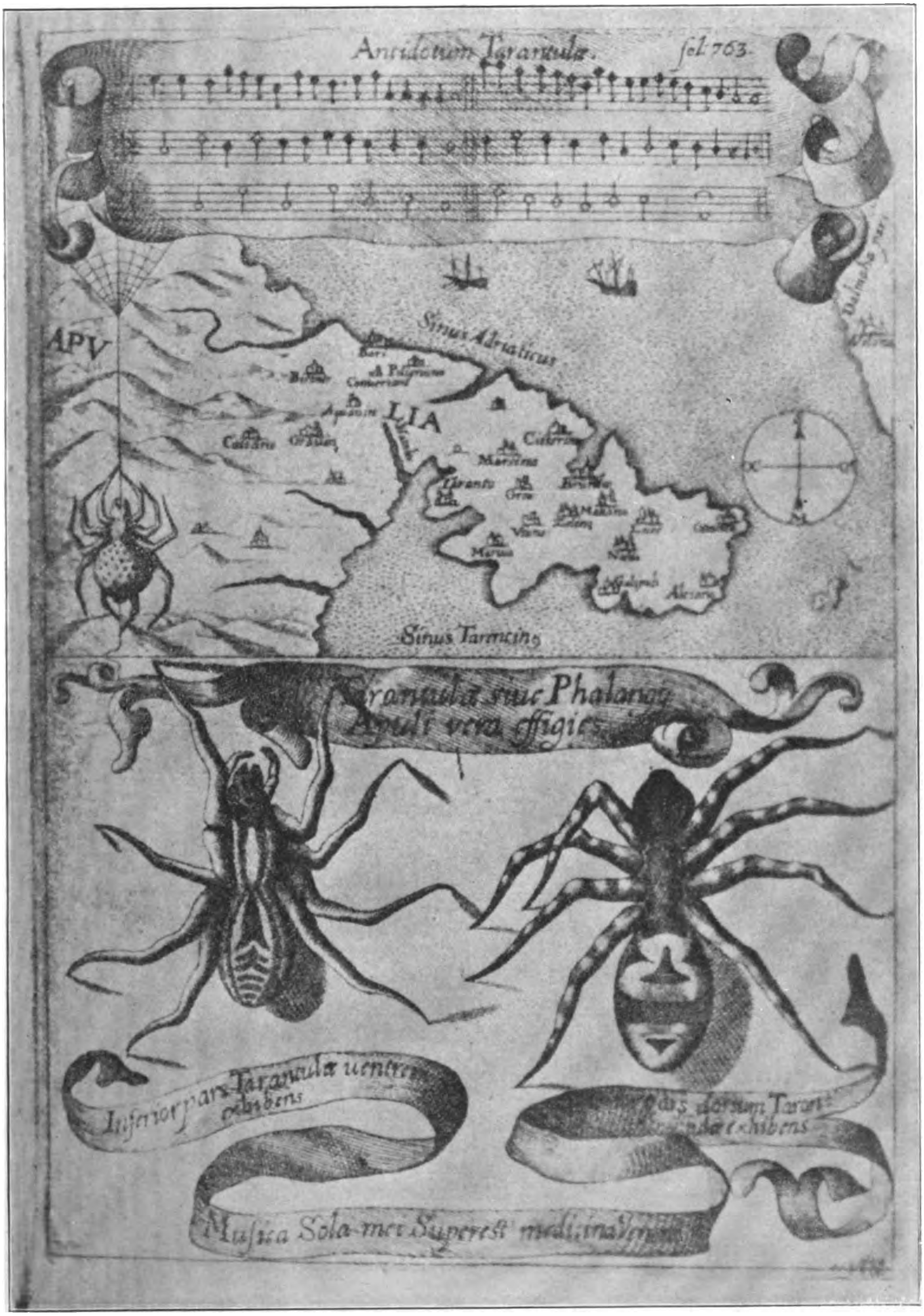
CAUSE OF BANANA DISEASE

Among the theses presented by the graduates of the Institute of Technology last year was one on the study of the life cycle of a fusarium and the effects of certain fungicides upon it. A fusarium is a parasitic fungus which causes destruction by producing dry rot in potatoes and causing scab diseases in various plants. One of the most recently discovered plant diseases produced by these fungi is the so-called Panama disease of the banana which, in a little more than ten years, has spread along the country bordering on the Atlantic from Mexico to Brazil. Although it is now certain that fusarium is the cause of this disease, the life history of the organism, that is, its mode of growth and its spore formation, is not entirely clear. The object of the author, Mr. Peter Masucci, has been to determine its life cycle and to find a poison that will kill the fungus.

The speaker described the technique of cultivating the fungus from a single spore, and spoke of the experiments with different kinds of toxic agents. There are three ways of combating such a plague: By prevention in the killing of the parasites before they reach their hosts; by cure of the diseased plants; and third, by preventing the spread of the disease through the use of infected implements by some sort of aseptic method. The investigation touched the first and third of these processes.

It was found that the ordinary fungicides here lose their virtue for the reason that the organic matter in the soil combines with them and makes them useless as poisons. Phenol and creosote have under these conditions but slight germicidal action. Bleaching powder, however, has proved to be fairly effective.

With regard to the disinfecting of freight cars, tools and other implements used in the plant industry, all of which are known to carry disease, Mr. Masucci finds that bleaching powder is here far more effective than formaldehyde or lime-sulphur. Its use can probably be relied upon to check the spread of disease through any of these channels.



From Magnus sive de Arte Magnetica (1643)

TARANTISM AND THE DANCING MANIA

Some people, in an effort to explain the modern dancing craze, have attempted to liken it to the remarkable dancing mania of the Middle Ages. Whether this is true or not, it is interesting to recall to mind the extensive outbreak of frenzied dancing which swept over a great part of Europe, particularly during and immediately after the tremendous epidemics of the Black Death. One of the earliest outbreaks to be completely described occurred in Aix-La-Chapelle in 1374. The following strange spectacle was noted: Men and women "formed circles hand in hand, and, appearing to have lost control of their senses, continued dancing, regardless of the bystanders, for hours together in wild delirium, until at length they fell on the ground in a state of exhaustion. During the paroxysms the victims had hallucinations and some asserted that they felt that they had been immersed in a stream of blood, which obliged them to leap so high."

This extraordinary disease rapidly spread to many parts of Belgium, Holland and Germany, where it was variously known as St. John's or St. Vitus' dance, according to the saint who was supposed to protect those afflicted. The malady was first considered the work of the devil and the clergy were kept busy in their efforts to exorcise the evil one. That the disease was contagious was obvious and the victims were prone to acute recurrences.

In Italy, where the disease later appeared, the learned Nicholas Perotti, in an account of the disorder, points out that no one had the least doubt that it was caused by the bite of the tarantula, a common ground spider, particularly plentiful in Apulia, a southern district in Italy. It is significant to note this early attempt to explain the malady on natural lines and subordinate the supernatural. From the insect the disease was given the name of *tarantism*. There was a general conviction that by music and dancing the poison of the tarantula was distributed throughout the whole body, and expelled in the sweat induced by the great exercise. Later on it became evident that even those who were not bitten contracted the disease. Inquisitive persons who came to see the unfortunates in their wild dances not infrequently stayed to participate. Relief could only be obtained by dancing until complete exhaustion was produced. The musicians, who in some instances were employed by the municipality for this special purpose, were under no circumstances allowed to stop and substitutes had to be employed to relieve musicians who were themselves literally played out. As time went on it was noted that special kinds of music were very effective in bringing about the speediest cures. Music which permitted quick lively dancing was most efficacious. A rapid music imported from Turkey soon became the standby and was given the name of tarantella, a term still used to describe a rapid whirling dance. The accompanying illustration taken from Athanasius Kircher's *Magnes sive de Arte Magnetica* (1643) shows the tarantula, a map of that portion of Italy first affected and a few stanzas of music labelled *Antidotum Tarantulæ*.

Tarantism was at its greatest height in Italy in the seventeenth century, long after the disease had disappeared in Germany. From this time the disease decreased but has appeared on occasion among special sects as for example the Convulsionnaires in France, the Holy Jumpers and the Barkers in England, the Holy Rollers in the United States.

Space prohibits a discussion of the disease itself, suffice to say that it is definitely known to be a nervous disorder akin to an imitative hysteria. It is doutbful if we shall ever see such widespread affections, but we may expect occasional outbursts of a similar character in connection with fervent revival services and the like. The poor physical and mental condition of the people in the past produced through poverty, plague and other disasters undoubtedly played no small part in preparing their minds for the disorder of the Dancing Mania.

S. M. G.

Science Conspectus

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VOL. VI 1916 No. 3

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

VOL. VI | 1916 | NO. 3

THE PLAINS OF NORTHWESTERN CANADA

STORY OF THE VARIED GEOLOGICAL CHANGES THAT HAVE CO-ACTED TO PRODUCE THESE VAST TREELESS PLAINS AND GREAT ALLUVIAL BASINS

BY D. B. DOWLING

THE plains of Canada form but a portion of the larger plains of the continent, which occupy a large part of the interior and are divided into an eastern and a western portion by a great central valley. The eastern plains which extend to the St. Lawrence lowlands are forested and, therefore, are seldom referred to as plains. Westward, the rainfall being lighter, there is a thinning of the forests and there are more open areas. These are generally referred to as the plains. In Canada the open prairie of the plains is being invaded by the forests from the north, so that a division can be made of treeless plains, plains with scattered trees, and forested plains.

The first requisite in a definition for these plains would perhaps be, a nearly level surface supplemented by a soil covering and a climate admitting of the production of some vegetation, for the absence of moisture soon produces desert conditions. The formation of a level surface, to take a homely example, suggests either *planing* or *plastering*. The planing process of nature is a slow decay of the old surface and its removal by erosion. The surface thus planed is inclined to be rocky and, as it is losing its rock waste, the soil is to be found sparingly in the hollows or valleys. In plastering, the nature process consists of the spreading out generally by large bodies of water of the rock waste poured in by the streams. This produces a more perfectly even surface outline than is ever produced by the planing process, but our surface features are the product of both. If the surface were a part of a perfectly rigid sphere it would be difficult to explain the presence of large areas containing the rock waste or of those plains built up by the spreading action of the sea, but, as there is a vast amount of evidence showing that the continent has not been stable but sank in certain areas, rose in others, and repeated the sinking and rising several times, we are forced to believe that the crust is flexible and that its equilibrium is influenced by tangential strains or the shifting of load. To this we owe the submergence of those parts which received a coating of rock waste deposited by the sea. Much of this rock waste underlies the great agricultural areas or plains so that we may say that the flexibility of the crust made possible the peopling of the earth by providing soil covered areas for the plant growth necessary to support the animal life. The plains of North America bear in their underlying rocks the record of long invasions of the sea and these form a part of the history of a continent which seems to have been a very old feature.

Much of its early history is very

FIG. 1. The Manitoba Lowland and The Plains, a representation of the surface on an exaggerated vertical scale, looking west. Lake Winnipeg in the foreground

obscure but we know that at several periods the ocean encroached and almost submerged the continent. The maximum submergence was probably in Ordovician times when much of the limestone deposits of the continent were formed. Later, the seas seemed to have been shallower and the rocks, formed by the débris entering the sea, were of a fragmental character and became better soil makers. The plains of eastern America owe most of their fertility to the decay of these rocks, but the western plains, now called the Great Plains, received still further treatment beneath a shallow muddy sea which covered the sandstones and limestones of the former plain by a heavy coating of mud now hardened to shale. Then when the sea invasion was about over, the great mud flats supported a very rich vegetation which is preserved in coal seams. The later additions to the building of the plains consist of coarser material and indicate a nearer source of supply which means an elevation of the land underlying and adjoining the western edge of the basin. With the draining away of the salt water there was an additional elevation in the land area which amounted to mountain building. This consisted of the formation of folds as a partial relief from the tangential strain, but as the movement continued probably too rap-

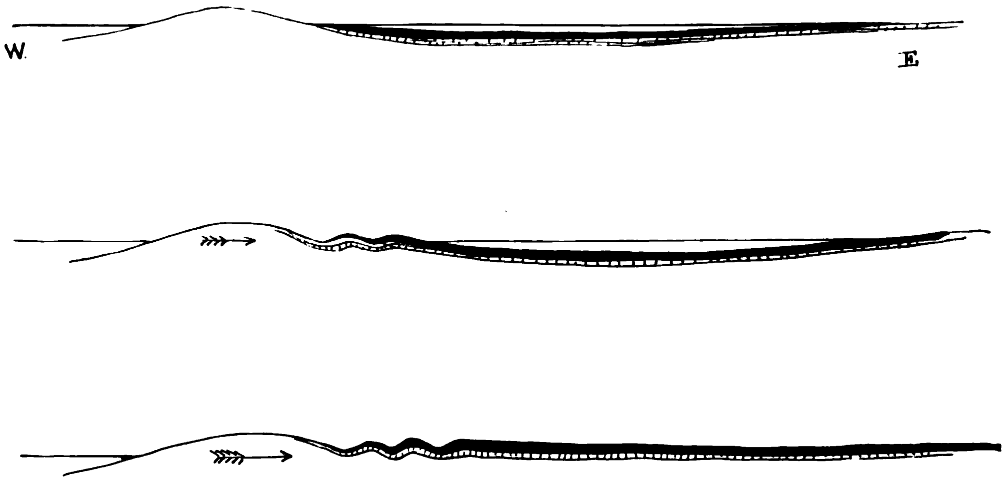


FIG. 2. Diagrams showing Cretaceous basin and its elevation by tangential stresses

idly for the material to follow without fracture, most of the folds became broken.

We thus find, as a typical structure in the Rocky Mountains, fault blocks piled one against the other in regular succession, repeating the same series of beds many times. In front of the broken area or to the east of it, folds and breaks of less intensity and lower elevation occur at present and towards the east the decreasing disturbance in the rocks show very clearly that the strain was from the west. The formation of the Rocky Mountains is about coincident with the elevation of the plains, for in their slow rise the soft rocks forming the covering of the broken folds were washed down and carried across the plains by the streams or spread out in lakes. On the completion of the first period of erosion, after the appearance of the outer mountains, the plains presented probably a rather rough, rock strewn surface on the higher slopes. The removal of much of this débris was made possible only by a further elevation and with a steepening

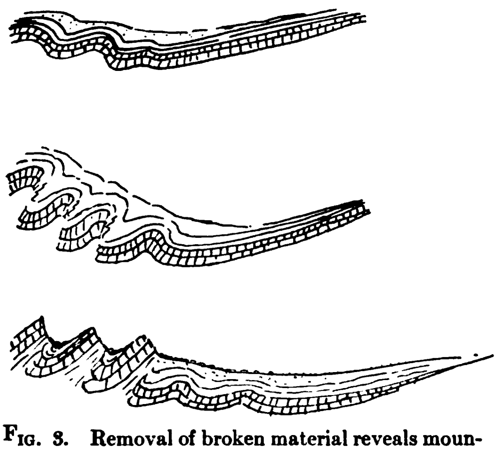


FIG. 3. Removal of broken material reveals mountain structure

of the slope eastward the second scoring began. This was continued until from the surface hundreds of feet were removed. The cycle of denudation was not completed, as is shown by remnants of the first surface which still remain.

The coming of the ice sheet of the glacial period is thought to have altered the general topography but little, with the exception perhaps of a smoothing of the uneven surface or a filling up of sharply cut valleys. The period during which the ice was wasting or melting is marked by many drainage channels that are now abandoned. The occupation by the glacier of the valleys of the prin-

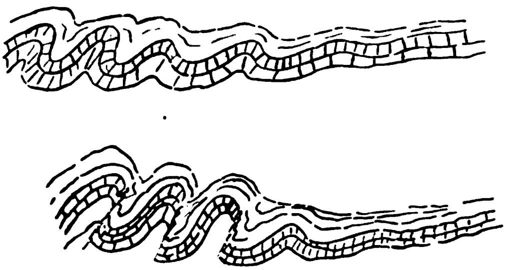


FIG. 4. Continuation of folding to the breaking point

cipal streams which have a northeastward trend caused no doubt a damming up of the water which, together with that from the melting ice, overflowed along the ice front and sought channels that were almost at right angles to the original channel. Many of these are still used as parts of the present river courses, but in the southern portion of the Canadian plains there are many of these glacially induced channels that are now abandoned and have apparently no other reason for their existence. The Saskatchewan drainage was diverted to the Missouri for a short period while its former valley through the Coteau was blocked by ice. The diversion filled Lakes Chaplin and Johnston and proceeded south, scouring out the valley now occupied by Lake of the Rivers, Willowbunch and Big Muddy Lakes. A little later the outlet was shifted to east of the Coteau and the Regina plain was a lake basin drained by the Souris River probably to the Red River valley. This lake was lowered by the retreat of the ice to a position farther north and a new channel was again adopted. This was deeply cut by the flowing streams and is now used by the Q' Appelle and Assiniboine Rivers which have but a small flow at present.

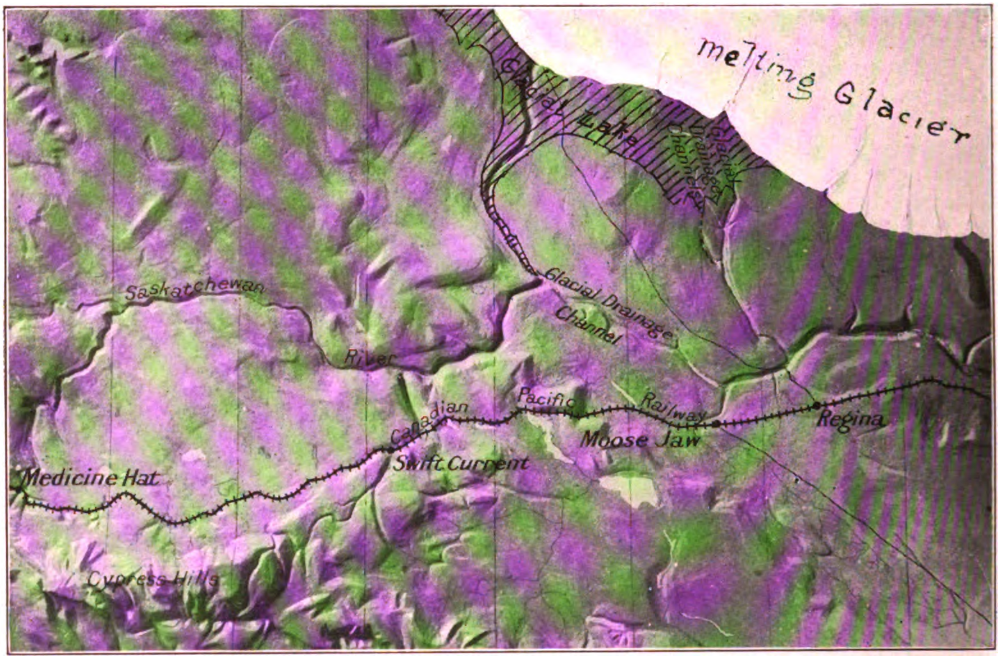


FIG. 5. Diversion of Saskatchewan River. Illustrating one stage of the retreating ice front across the plains. (Note—Modern names and railway could not be deleted)

The melting of the ice in the lowlands of the Red River valley created a lake along its front of the ice that was not as readily drained as was the case in the retreat of the ice cap across the prairies. In the Red River valley there seemed no outlet and the basin filled until it spilled over its lowest point, far south in Minnesota at Lake Traverse. The removal by melting, of a vast mass of ice in the north, seems to have resulted in a slight elevation of the crust that had been depressed by the weight of the ice. This recovery which means an actual tipping of the lake basin lowered the lake by spilling its water to the south and as the lake at its several stages formed beaches, the levels of these give us the amount of tilt that occurred between their dates of formation. This outlet was abandoned when the lake secured a lower northern outlet. The greatest depth of water over the site of the city of Winnipeg was about 560 feet.

The benefit of this old lake to the agricultural value of the Red River valley can hardly be measured. Over the surface of the boulder clay, which covered the limestone outcrops, the waters of the lake spread a thick coating of the finely ground shale that was excavated in the digging of the several large valleys that cut through the plateau to the west. This deposit in lessening amount or thickness is found over the lake basin area north of the Red River valley and underlies the plains around Dauphin, Swan and Red Deer Lakes.

On account of the soft nature of the rocks the stream valleys are deeply incised which adds to the difficulty of using this passing water on the upland where it is often needed since the rainfall is barely sufficient during some seasons to make up for the evaporation. Were these rivers nearer the surface the question of diversion would be simple but long and expensive canals are required. The surface is generally treeless owing to the light rainfall. Tree planting is

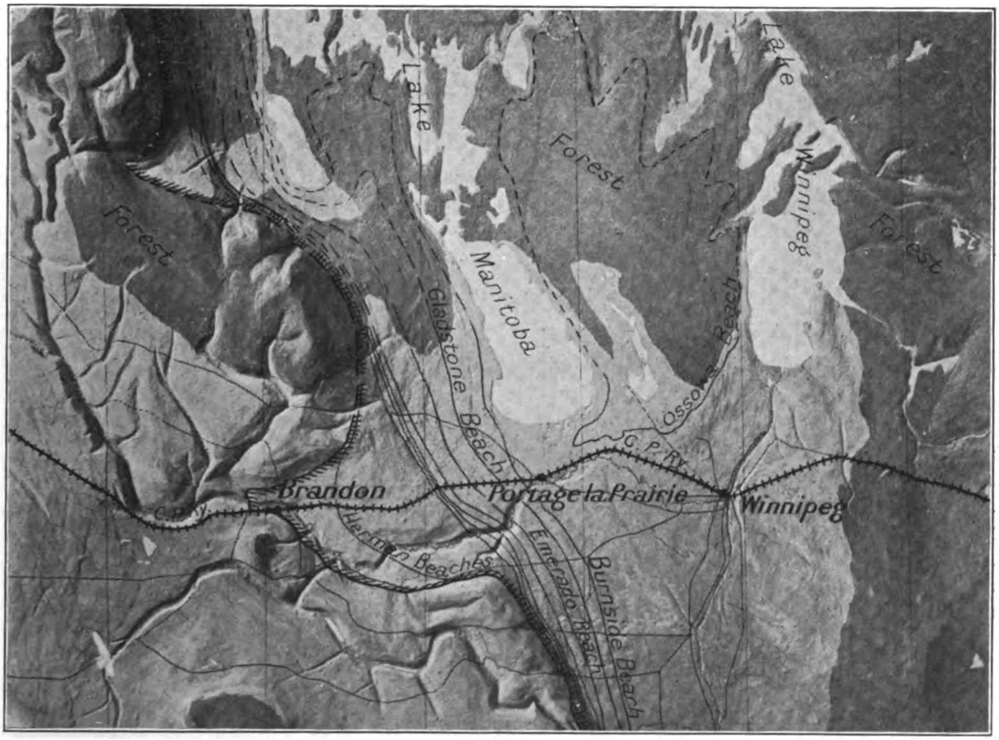


FIG. 6. Manitoba Lake Basin showing present lake levels with outline of beaches at higher stages (Lake Agassiz)

proceeding rapidly and is quite noticeable in Manitoba where the bare prairie is rapidly disappearing. This, if it does not induce a much greater rainfall, retards the evaporation of the ground moisture.

As a short summary we may repeat that the basin, which received the muddy deposits of Cretaceous time, has had a varied history. The rocks of the western margin were elevated and broken into long narrow blocks which are piled up in succession to form the Rocky Mountains. A second strip was strongly folded but not elevated as high as the mountains and constitutes the foothills. A third strip formed a ridge in advance of the folded foothills and now shows a simple synclinal structure, while the remainder, less disturbed but sloping generally to the east, forms the Great Plains of the northwest provinces.

UNUSUAL LIGHTING EFFECTS

UNUSUAL lighting effects were features of the spectacular masque and pageant given in connection with the dedication of the new buildings of the Massachusetts Institute of Technology. Thirty-four 1,000-watt stereopticon projectors fitted with nitrogen-filled lamps were installed at intervals of 3 feet 3 inches on the roof of one of the buildings for the purpose of flood-lighting and spot-light effects, while a similar arrangement was installed on the roof of a facing building. There were four 1,000-watt projectors, each in a pit with a glass cover, for securing lighting effects in the central ring, and four 250-watt units, also in glass-covered pits, for illuminating jets of water used in connection with the water dances.

SAFE CANDY

HOW FEDERAL FOOD SUPERVISION AND THE INVESTIGATIONS OF SANITARIANS HAVE RAISED THE STANDARD OF THE PRODUCTS OF THE CANDY INDUSTRY

BY S. C. PRESCOTT

THIS is the candy age. Candy in some form is found in practically every household. Gifts of candy are made by hundreds of thousands and appear to be ever acceptable. It would be difficult to estimate with any degree of accuracy the number of tons of sweets which pass from retailer to consumer during the holiday season. Some of it has been of the highest grade, some of lower commercial quality, but it has all added to the enjoyment of the season. Each year candy becomes more and more contributory not merely to the holiday period, but to the enjoyment of life at all times and places. The candy or confectionery industry has in ten years nearly doubled and in twenty years has developed from an insignificant position into one ranking easily in the first score in the value of the output and number of hands employed.

In Massachusetts, for example, confectionery ranks fifteenth among the industries of the state in the value of the product and there are employed in the candy factories in this state alone over six thousand persons. Thus the industry has developed not merely into a permanent and important one, but one liable to still further marked increase, for while candies must still be regarded to a great extent as luxuries, their consumption is constantly increasing among all classes of people. Because of its importance it is apparent, therefore, that the industry should really be grouped among the food industries.

Of the usefulness of good candies there can be no question. Despite the early prevailing opinion that all candies were unwholesome, caused digestive disturbances, and were primary causes in the decay of the teeth, it is now recognized that good candies are high in food value, entirely wholesome if used in moderation, are no more predisposing causes of decay of teeth than other carbohydrate foods, and supply to the body *energy* in large amounts and in quickly available form. In other words, here is a *special food* which we may still regard as a semi-luxury but which, none the less, does bring to the consumer a marked amount of available energy as well as the pleasure derived from its consumption. In fact the craving for sweets which is sometimes manifested not only in children but also in adults should be regarded as a perfectly normal demand of the body for a certain class of carbohydrate foods and not an unhealthy appetite, and it has been suggested that when this craving is satisfied, others, as for example for alcohol, disappear or are greatly lessened. Assuming, therefore, that candies are to be regarded as special types of foods, even if not absolutely essential types, the position should be taken that they, like all other manufactured foods, should be subjected to such processes of inspection and treatment as will *guarantee the quality of the raw materials, safeguard the hygienic or sanitary character and maintain the high food value conditions of the product.*

As with other commodities a great range of products may be obtained, varying from the very expensive and attractive in appearance to the very cheap and unattractive; from the high-class goods produced under good sanitary conditions to those which have little to recommend

them either from the standpoint of quality or cleanliness in production and handling.

This great development in the scope of the business has been made possible partly because of the study which has been given to the manufacturing, but particularly because the scope of raw materials entering into the composition of these candies has been greatly increased. Thus the use of corn syrup, chocolate, dried and evaporated milk, eggs, albumen, gelatin, and the great variety of fruit and nut products, have made it possible to secure the great variety of products which we have at our disposal, and it may be emphasized that their use is absolutely unobjectionable so long as they are pure, clean and wholesome.

The importance of the industry from the standpoint of *public health* is, however, quite as noteworthy as its commercial importance. With the constant increase in consumption we must demand safe candy. Here is an industry in which the product passes directly and sometimes quickly from the hands of the worker in the factory to the mouth of the consumer. Public welfare demands that the greatest care should be taken that all *substances* used in the manufacture of these products should be free from objection from the hygienic standpoint, that the *processes* should be carried out under sanitary conditions and with every attempt to prevent contamination, and that the *employees* should be under such strict supervision that there can be no possibility of infection by undesirable bacteria of these materials which go directly without cooking into the mouths of the consumers.

From very early times sweet products have been highly regarded, and candy making was apparently an accomplishment practiced by some of the Romans, who had booths along the Appian way for the sale of their alluring products. That they were not always of the highest quality would seem to be evident from the statement of Cicero who somewhere alludes to "the filth and reeking sickness" produced by their consumption (or abuse?), and who suggests the need for some control of their preparation so that it would be possible to "seek out those doing harm and put punishment on their heads." Evidently the need for sanitary inspection of materials or processes was acute, and a portion of the candied products was not "safe."

It may be pertinent to inquire what "safe" candy is. Primarily it is that which will do no harm to the consumer. This means that the ingredients contain no poisonous chemical substance, and that there is not lurking within an attractive exterior the living germs of disease.

A candy may be "safe" and still be inexpensive. Just as we must recognize commercial grades in fruits, or in tea, or coffee, or in eggs or in a thousand other commodities, we must also recognize commercial grades in candy. If Mr. X. can retail chocolates at forty cents while Mr. Y. charges eighty cents a pound, there is obviously likely to be a difference in the commercial values of the materials used, or in the skill used in making, or the way in which the package is presented to the consuming public. But either one of these products may be "safe." One may be quite as wholesome as the other without having the same attractiveness. On the other hand, it is possible that neither might be "safe," although on this point the chances are fortunately very small.

With the working of the food laws, and care taken by the large dealers of excellent reputation who produce a very large percentage of the candy sold, dangers from adulteration with dangerous chemical substances is extremely uncommon. From this standpoint most candy is "safe."

This fact, however, is not as widely accepted at present as it should be. Within a year there appeared in large headlines on the front page of a Boston paper the announcement that several children had died as a result of eating poisonous candy. The article went on to say that this candy had produced "aci-

dosis," and that chemical examinations of some of the candy had shown the presence of a "powerful acid" in the candy. Of course those who are familiar with the manufacture of candy at once said: "Impossible, this cannot be true." "The statement is the result of the disordered imagination of a reporter." But what of those who did not know of what materials candy is made? In twenty-four hours or even less, the report that candy had been the cause of the deaths was denied. There was no real evidence against candy at all, although the actual cause has not been elucidated. If the children ate Christmas candy it was probably safe candy, unless it had become contaminated from the fingers of some one who had handled it.

The contamination of food materials may be brought about by one of several different methods or by combination of them. The raw materials themselves may be objectionable, for example, certain of the materials used in candy may contain salts of arsenic, zinc or lead, sulphur dioxide, formaldehyde, or other substances which are prejudicial to health. As a matter of fact, the candies manufactured by reputable dealers do not contain these substances. In the second place, contamination may take place from dust infection due to dirt blown in from the street, dust from floors, and it is conceivable that such germs as diphtheria bacillus and tubercle bacillus might gain entrance in this way. Here again the observed facts are strongly against the probabilities of such an occurrence. In high class candy factories care is taken in regard to the ventilation and also in regard to the floors, as obviously dust gaining entrance to the goods brings about objectionable discoloration and renders the product less attractive and appetizing. In the third place, contamination of candy might result through the handling by operatives who are suffering from various kinds of disease but in which the disease has not reached such an advanced stage as to be apparent. It is from this source that danger is to be apprehended and it is on this point that the greatest care is demanded of the manufacturer. From what we know of "carriers" at the present time it is unquestionably true that those who handle our food substances in any way may subject it to a certain amount of contamination.

The chief way in which candy may be rendered unsafe is by the contact with polluted fingers of the occasional disease "carrier." Suppose a chocolate dipper had typhoid last summer, or it may be years ago, and became a "carrier." She might appear in the best of health and yet daily produce typhoid bacilli in large numbers, which without an unusual lack of personal cleanliness could in part find their way to the chocolates. The probability of such carrier infection is slight. No case has yet been reported, but if manufacturers are wise they will exclude from dipping or packing rooms all persons who have had typhoid and who have not been proved by medical examination to be not a carrier. As carriers give away their germs by contact, it might happen that other workers near by, especially if close friends, might be infected. This source of danger could be largely eliminated by requiring that those handling foods should be vaccinated against typhoid. In fact this treatment is to be recommended to all in any case as a safeguard against a dangerous disease which is all too prevalent in America.

In some experiments carried out in my laboratory with my former student and associate, Mr. E. H. Cummins, we found that typhoid bacilli would survive in chocolate for long periods of time, although the numbers were greatly reduced. For example, we found in a chocolate containing 4 per cent. of water and to which 400,000 bacilli per gram were added, that only 24,000, or 6 per cent. survived after 140 days. In a chocolate containing 8 per cent. water we put an average of 260,000 per gram. At the end of 40 days 15,000, or about 6 per cent., remained alive. In a chocolate containing 29 per cent. water the initial number in-

troduced was 200,000 per gram. Here, after 225 days, typhoid bacilli were still found in considerable numbers. The most interesting thing revealed by this particular test was that in forty-eight hours the number was almost as small as after 225 days, indicating that a large percentage would die on the first few days in case of an infection such as I have imagined.

Our work has, on the other hand, also had some most reassuring results in the study of the survival of other kinds of bacteria, for we found the bacillus of tuberculosis to disappear in a very few hours, as did also other germs.

It is probably fair to assume that it is only rarely that a heavy infection would take place in the handling of candy, but it is well for the manufacturer to be keenly alive to any opportunity, however remote, by which his product could be the means of distributing disease.

From the foregoing statements it should be apparent that the candy industry as a branch of the greater food industry is on the whole, in a very satisfactory condition. The larger dealers, and they manufacture the preponderant percentage of the candy sold, have found it of advantage to maintain conditions of cleanliness and to have a strict regard for the purity of their raw materials. The results of tests by introducing bacteria into candy are also reassuring since they indicate that it is only the occasional type of germ which will survive for any extended period, other forms quickly disappearing owing to the lack of suitable nutrition. All of the high class candy may therefore be regarded practically as "safe candy" providing it is not subject to dust infection and to unlimited handling by people of unclean habits.

The exposure of penny goods in nooks along the street and other places where wind can bring about wholesale dust infection from the ground-up material from the street must be regarded as objectionable and dangerous. Similarly, the manufacture of candies in ill-lighted basements where no attention whatever is paid to sanitary supervision either of apparatus or operatives must be looked upon with distrust. Agencies which are at work within the industry will undoubtedly very largely remove these objectionable features. Furthermore, the coöperation which is constantly extending between the operatives and the employer in the matter of welfare work, conditions of labor, hygienic supervision, provision for rest rooms, proper toilet facilities and other agencies of cleanliness, and in many instances visiting nurses and physicians, are constantly raising the standard of the products of the industry. On the whole, it would probably be difficult to point out any branch of the food industries where the improvement had been greater and where the product goes to the consumer with a higher degree of protection.

FOUR-DIMENSIONAL VISTAS

In the introduction to his book "Four-Dimensional Vistas," Mr. Claude Bragdon says: There are two notable emancipations of the mind from the tyranny of mere appearances that have received scant attention save from mathematicians and theoretical physicists.

In 1823 Bolyai declared with regard to Euclid's so-called axiom of parallels, "I will draw two lines through a given point, both of which will be parallel to a given line." The drawing of these lines led to the concept of the curvature of space, and this to the idea of *higher* space.

The recently developed Theory of Relativity has compelled the revision of the time concept as used in classical physics. One result of this has been to introduce the notion of *curved* time.

These two ideas, of curved time and higher space, by their very nature are bound to profoundly modify human thought. They loosen the bonds within which advancing knowledge has increasingly labored, they lighten the dark abysses of consciousness, they reconcile the discoveries of western workers with the inspirations of eastern dreamers; but best of all, they open vistas, they offer "glimpses that may make us less forlorn."

FLIGHT IN ANIMALS

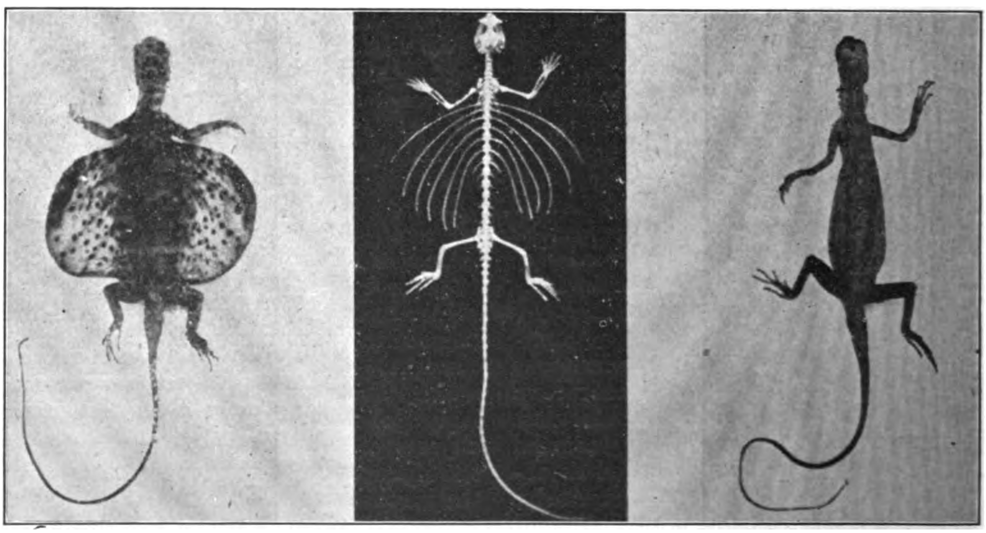
A BRIEF SURVEY OF THE HISTORY OF GLIDING AND TRUE FLIGHT IN ANIMALS—EVERY CLASS OF VERTEBRATES HAS HAD FLYING REPRESENTATIVES

BY H. W. SHIMER

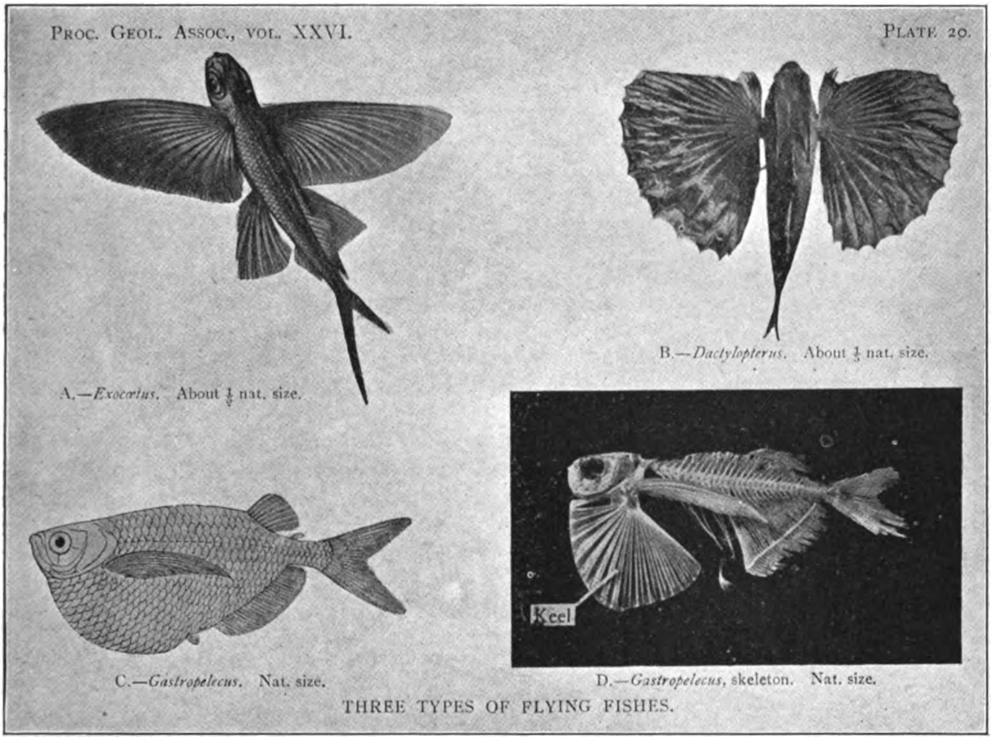
THE art of flying is a late development upon our earth. First acquired in the late Paleozoic by the insects, it apparently did not appear among animals with a back bone until the succeeding era, the Mesozoic. Animals as well as plants first acquired the ability to live in water; later, as the waters became crowded, the land was invaded, and it was but natural that when these two realms became densely populated, representatives of the highest groups of animals—insects and vertebrates, should seek food and safety in the air.

Flight among insects has been wonderfully successful. Since, however, their peculiar mechanism limits them to small forms they are entirely at the mercy of heavy winds and hence can not compete with the heavier and more muscular vertebrates.

It is noteworthy that every class of the latest animal phylum to appear upon this earth, the vertebrates, has flying representatives. Of course the art varies enormously in the fish, amphibians, reptiles, birds and mammals. Some are merely gliders; others are true fliers. The typical gliding membrane, the patagium, consists of a double fold of skin extending along the sides of the body connecting to a greater or less degree the fore and hind limbs and at times also the tail. This skin acting like a parachute enables the animal to glide through the air without muscular effort and usually only in a downward direction. Fliers are able to sustain themselves in air by



Draco Spilopterus—1. Patagium expanded. 2. Skeleton showing elongated ribs. 3. Patagium closed



THREE TYPES OF FLYING FISHES.

muscular effort and alter their direction or altitude at will. True flight is confined to birds, bats and the extinct flying reptiles, the pterodactyls.

Since fish breathe by gills they cannot leave the water long and have hence developed few flying representatives. The flying organs of fishes are usually the very much enlarged pectoral fins. In some species of Exocoetus the fish may continue 300 yards at a uniform height of a foot or so above the water. The well known Catalina flying-fish (Exocoetus californicus) reaches a length of 18 inches.

The present day Amphibia are the insignificant remnants of the class which ruled the land during the later Paleozoic. Transitional as they are from a water to a land life it is not strange that no fossil flying forms and but a single living form are known. In the tree-dwelling "Flying Frog of Borneo" the feet are very large, with webs extending to the tips of the toes. With feet outstretched it is able to make great gliding leaps from tree to tree.

The comparatively few living reptiles which can fly belong to the gliding type. Draco, the Flying Dragon of the Malay Peninsula and Pacific Islands, of which there are some twenty species, is a small arboreal animal about a foot in complete length. In Draco the patagium is supported by six very long ribs.

During the Mesozoic era of earth history, however, reptiles possessing the power of true flight were very numerous. These had large membranous wings consisting of a double fold of skin stretching from the sides of the body to the ends of the greatly elongated fore limbs. That these extinct animals were good fliers is shown by the fact that, like birds, many bones are hollow, the skull is large and light, the breast bone is flattened and their fossil remains are frequently found in deposits estimated one hundred miles from the nearest land.

In birds the flight apparatus is entirely

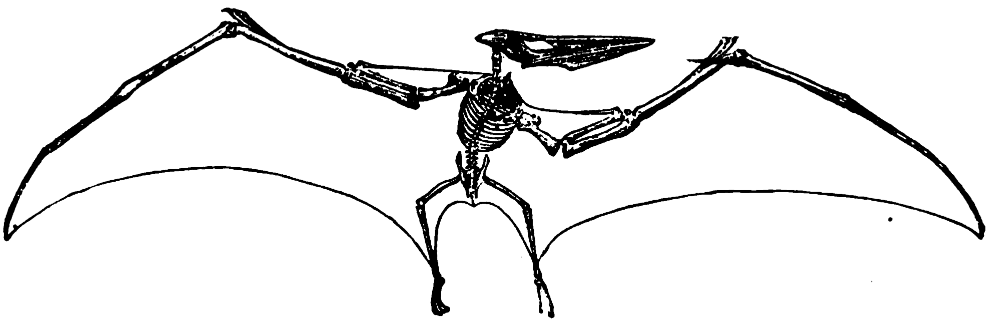
unique, and has proved wonderfully successful. Instead of a patagium there are specially developed feathers borne upon the fore limbs, the air beating organs. Since microscopically these feathers consist of interlocking hooklets and ridges, the resultant is a very efficient, though light, apparatus for striking the air. The earliest birds, appearing in the Mesozoic, possessed sharp teeth and a long vertebrated tail with a pair of feathers attached to each vertebra; gradually, however, the teeth disappeared and the long tail became shorter and shorter until among living birds it consists of some six small vertebrae and a vertical terminal bone; this last represents a fusion of several vertebrae and around it the tail feathers are arranged in a semicircle. This enables the bird to become lighter in weight without interfering with the efficiency of the tail as a rudder.

Among the eleven living orders of the class of mammals at least four possess members capable of some measure of flight. Of the four, marsupials, rodents, insectivores and bats, only the last are true fliers; the others are merely gliders. In all, unlike birds, the flying or gliding organ is a patagium, a double fold of skin upon each side of the body between fore and hind limbs.

In the marsupials this power is limited to the arboreal family of phalangers. These flying forms, confined to the Australian region, have the patagium extending down to wrist and ankle. They vary in size from that of a small mouse to a length of 20 inches from snout to root of tail.

In rodents, gliding is confined to the members of two allied families, the African flying squirrels and the true flying squirrels. Of the latter, one species occurs in the United States, the rest are confined to the Old World and are almost restricted to the Indo-Malayan region. They vary in length of body, exclusive of tail, from 5 inches to 12 inches. The patagium usually extends to wrist and ankle.

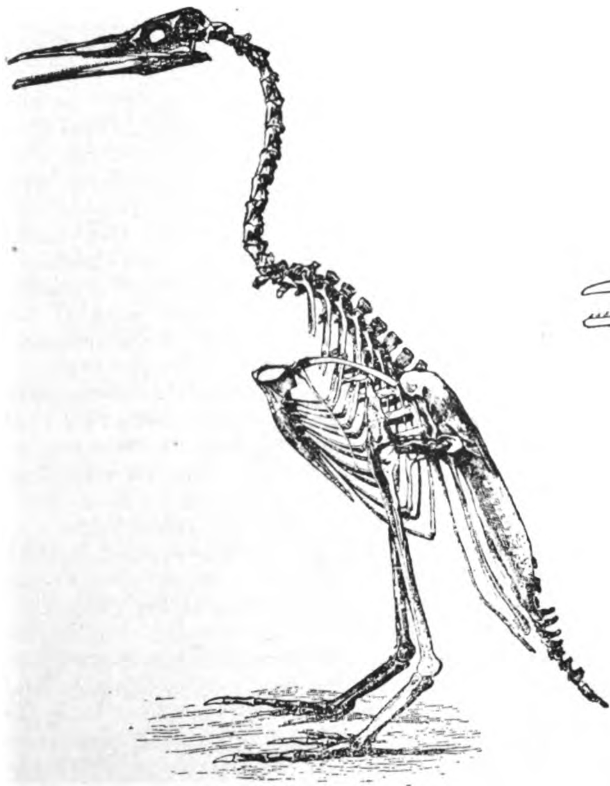
The order Insectivora possesses only the so-called Flying Lemur,—Galeopithecus; one species confined to the Malay Peninsula and Pacific Islands, the other to the Philippine Islands. In these the patagium is very large, extending to the tips of the toes and the end of the tail.



Pteranodon occidentalis—Span of wings 18 to 20 feet

In bats, the only true flying mammals, the patagium embraces limbs and tail, and is especially extended over the greatly lengthened fingers of the hand to produce an efficient organ for beating the air. The skeleton is very lightly built and the breast bone, as in birds, has a keel for the attachment of the wing-muscles. Bats represent a successful mammalian off-shoot, as they are found all over the world and even within the Arctic circle. They vary in size up to a spread of wing, in the Flying Fox of Java, of 5 feet. They occur fossil from early Tertiary (Upper Eocene) to the present.

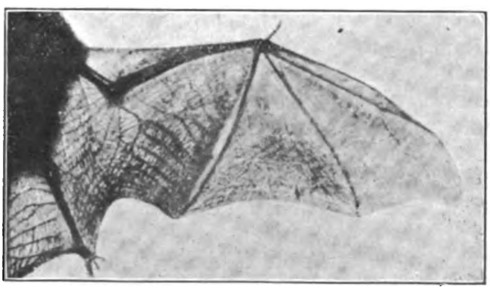
Aside from the insects, Nature's first



Hesperornis regalis—Height about 3 feet

Ichthyornis victor—Height 10 inches

experiments in flight appear to have been in the early Mesozoic among the fish. Forms with enlarged pectoral fins, the typical flight organ of fish, were developed independently in different families, at intervals from the Triassic to the present. Among the reptiles and mammals the patagium is the flight organ. From the primitive form seen in the Flying Gecko where the patagium is merely a fringe of skin extending along the sides of the body, limbs and tail, through the flying phalangers and squirrels where these fringes are enlarged to form broad expansions between fore and hind limbs, to the much enlarged condition in the flying lemur, Galeopithecus, flight occurs with body held rigid. If the animal acquired the habit of jerking or waving its limbs during flight, modification of these limbs might take place and a true wing be produced. This has occurred independently among the reptiles in the pterodactyls and among the mammals in the bats; the former made their first appearance in the early Mesozoic disappearing with its largest members in the late Mesozoic; the latter appeared in the



Patagium-wing of Bat, showing enlargement of four fingers

early Tertiary, their largest representatives living today. Birds were contemporaneous with the pterodactyls but were not numerous until the early Tertiary after the disappearance of the latter. It is interesting to note that while the early representatives of flying reptiles, birds and bats had a long vertebrated tail, this had disappeared completely in the later pterodactyls and in bats, while in birds its place is taken by the fan-like tail feathers. Apparently a long tail as a steering organ is not a necessity. Another parallelism is seen in the gradual disappearance of teeth and the development of a beak in both pterodactyls and birds; whether this change will also occur in the bats of the future it is impossible to say.

(The above is largely a review of "The Geological History of Flying Vertebrates," by George W. Young, in the *Proceedings of the Geologists Association*, Vol. 26, pp. 229–265, 1915, London; to which we are also indebted for the figures.)

SELF-DIRECTION IN EVOLUTION

Self direction of activity and consequent control of environment become greater and greater from lower to higher forms of life. The protozoön slowly gropes, or darts blindly, hither and thither in search of food. The sluggish clam collects such edibles as happen to come within the reach of his suction pump. The tiger, with every muscle tense, ever ready for the final rapid leap, slowly creeps upon his prey. In man, active thought before deliberate rapid action is developed to an ever higher and higher degree. The higher protozoöns and the Saint Vitus dance victim both have physical activity highly developed, but in both, self direction of these actions is slight. Bodily inaction in man no more necessarily denotes active thought than does similar inactivity in the clam.

In the development of life upon this earth, we note a similar advance in organic activity from the early pre-Cambrian eras, through the Paleozoic and Mesozoic to the present Cenozoic era of earth history. The little we know of life in the time of the pre-Cambrian shows that it consisted of such low types as algæ among plants and protozoöns, sponges, etc., among animals, organisms with activity but slightly self-directed and almost entirely controlled by environment.

With the incoming of fish and of the primitive ancestors of the squid and devil-fish in the lower Paleozoic there occurred a decided advance in this connection; for these animals, with nerve centers concentrated into brains and with organs for rapid locomotion, could sense both food and danger at a distance and were thus enabled to change their environment to suit the needs of the moment. That is, environment had ceased to exercise so complete a control over their lives.

With earth's waters thus ruled by such highly developed animals, evolution shifted to the land, and there appeared in the Upper Paleozoic the amphibians, transitional from water dwellers to land dwellers, and next such typical land animals as the reptiles. This land life advanced still further during the Mesozoic for with the development of the earliest birds and mammals the highest classes of animal life were reached though not its highest expression, as these early species were the most primitive of their kind. It was in the Cenozoic, the present era of earth history, that these higher types evolved, finally culminating in the highest mammal, man. The amphibians, reptiles, birds, mammals and man form an advancing series in self-direction of activity and in a greater and greater independence of environment. In each class there is a similar advance from the primitive representatives, those appearing earlier upon the earth to the later appearing, more advanced types.

Thus organic life has developed from activity directed and controlled by environment to activity self-directed, the organisms understanding environment to an ever greater and greater degree and hence, to that extent, becoming independent of it.

HERVEY W. SHIMER

METHODS OF STUDYING COAL

HOW A NEW METHOD OF REFINED TECHNIQUE HAS REVEALED PLANT RECORDS TO THE INVESTIGATOR, ESPECIALLY WITH REFERENCE TO THE ORIGIN OF COAL

BY E. C. JEFFREY

COAL, since it is a mineral, has in the past been investigated with the aid of the admirable technical processes, which have been devised by the mineralogist and petrologist in the study of minerals and rocks. Fossil plants, also, have naturally been regarded as minerals, since in the condition ordinarily studied structurally they are petrified: that is, infiltrated or, in some instances, actually replaced by mineral substances. In addition to the relatively scanty petrified remains of fossil plants, which have previously been the most important document for the student of extinct vegetations, there are huge quantities of plants of former epochs, preserved for us by a more or less complete process of carbonization. This carbonization is so marked in some instances, that it is obvious that the plant remains have been charred previous to fossilization. The present writer has turned his attention to the utilization of these carbonized remains, in connection with the tracing of the all too incomplete geological records of plants. By the perfecting of processes of softening and bleaching these carbonized remains, it has been found possible to add very largely to our knowledge of the organization of ancient plants, particularly of the Mesozoic Age, concerning which our information has been most meager. Methods developed first for the investigation of isolated members and parts of plants, by modification have proved serviceable in the study of that structurally almost unknown mineral coal. Our ignorance of the organization of coal is not due at all to the neglect of mineralogists, but rather to the unsuitability of the approved methods of their science in the case of a substance at once so opaque and so friable. The advantages of the methods recorded here may be judged from the fact that they permit the cutting of large quantities of sections, which average one tenth of the thickness of the few and laboriously secured preparations resulting from the grinding processes of the mineralogist. Moreover it is possible to render the sections even more favorable for study by bleaching, which is inapplicable to ground sections. It should be added that the successful manipulation of the processes described in the subsequent paragraphs involves a considerable experience in the use of the microtome, the slicing mechanism of the biologist.

The more recent and less modified coals are treated for sectioning with comparative ease. Alcohol alone is frequently sufficient to bring about the necessary degree of softening for successful slicing. Such coals are of relatively light hue, and sections need not be so thin as is essential in the case of the older and more highly carbonized coals. In general, however, somewhat vigorous softening agents must be used in the investigation of combustible minerals, since pressure and temperature have often brought about a considerable degree of modification even in coals of tertiary and secondary origin. Caustic soda or potash dissolved in alcohol of about 70 per cent. strength in the proportion one part in ten is a very useful preliminary reagent but has been found for various

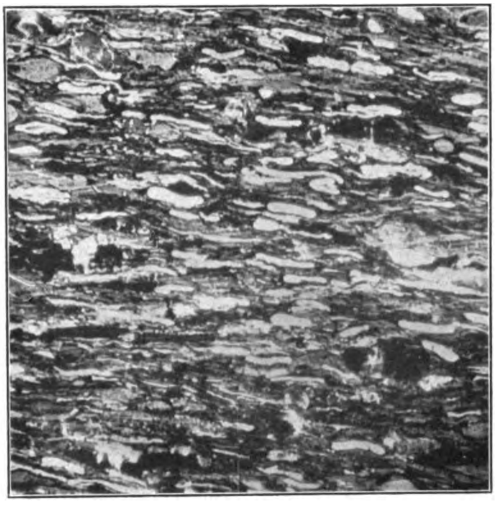


FIG. 1. Cannel Coal from Ohio, showing quantities of spores (light) and small fragments of highly modified wood (gray)

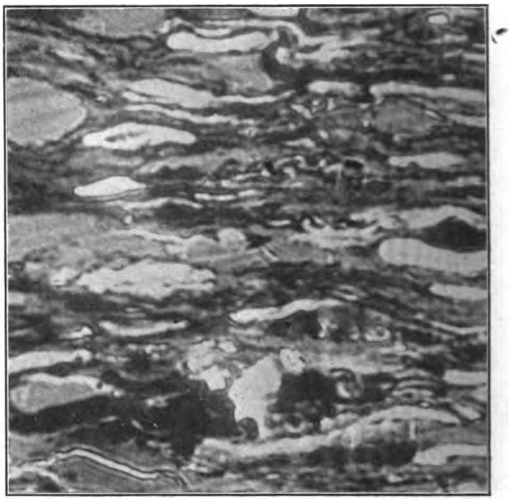


FIG. 2. Cannel Coal, upper left hand region of (1) more highly magnified, showing spores (light) and modified wood (gray)

reasons, less valuable in use than phenol. This substance has unfortunately advanced immeasurably in cost on account of its employment as a basis for the manufacture of high explosives in the present European war. The phenol or carbolic acid is melted and the selected coal samples (which must ordinarily not be more than a centimeter in length and breadth by half a centimeter in thickness vertically) are subjected to its action. The material is to be kept hot in a water bath for a number of days, usually as long as a week. The carbolic acid is then washed out with repeated changes of warm water. Heat and subsequent treatment with water after neutralization by means of an acid are likewise necessary in the case of material treated with alkaline alcohol, as described above. The advantages of the use of phenol in softening coal are that less swelling and cracking results than in the case of alkaline alcohol, and the material is in better condition for subsequent manipulations.

The removal of mineral substances from the coal is the next stage and for this purpose hydrofluoric acid is most generally employed. The fragments of coal remain in strongest commercial hydrofluoric acid for some days or even a week or more. In the case of coals neither much carbonized nor possessing a very high proportion of ash, the processes indicated suffice. In most coals, particularly those of the Paleozoic period, after treatment with hydrofluoric acid, the combustibles must be washed for a day or two in running water and then returned to the phenol for a renewed sojourn in the heat. This second softening in many cases is sufficient, but where a higher degree of carbonization is present, a second treatment with hydrofluoric acid is needed. In still more resistant coals the processes must be further repeated and the acid is reinforced in its action by adding crystals of chlorate of potash or soda, which brings into play the activity of nascent chlorine. With anthracites and other coals of an extreme degree of carbonization, nitric acid may be added with advantage to the hydrofluoric acid and chlorate of potash, but in moderation so that maceration may not result. The treatment with hydrofluoric acid and accompanying reagents, where these are necessary in the case of more refractory coals, is carried on in wax bottles or in glass bottles coated both

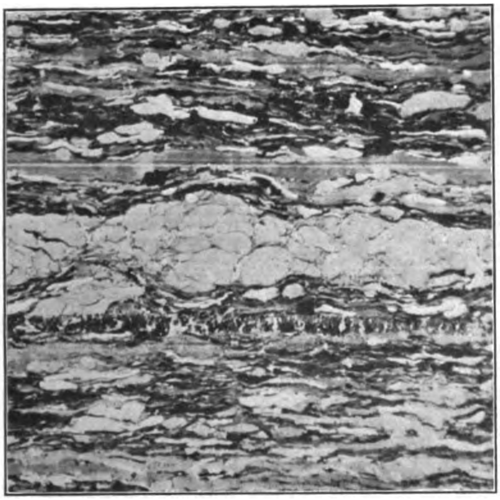


FIG. 3. Bituminous Coal, Lancashire, England, showing numerous spores (light) and more abundant modified woody material (gray)

FIG. 4. Bituminous Coal, Hocking Valley, Ohio, showing comparatively few spores (light) and a large quantity of wood (gray)

externally and internally, with hard paraffine or beeswax. A fume-cupboard with heavily painted windows is safe and convenient for this work, particularly if it is built over a soapstone sink.

After the coal is softened and bleached (as is the case where chlorates and *aqua regia* are used), it is carefully washed in running water until quite free from the reagents. In the case of highly bituminous coals, particularly cannels and the like, the pieces may be returned to melted phenol for some days. With most coals, especially those of later geological ages, it is necessary to wrap the specimens with bands of cotton fabric, held in place by stout linen thread. This precaution prevents the coal from going to pieces in the phenol. After the last treatment with carbolic acid, the combustible is washed repeatedly with warm water and then transferred to strong alcohol and finally to absolute alcohol, to remove all the water. Two or three changes of absolute alcohol are necessary. After the water is entirely removed the specimens are exhausted of all air under an air pump of high vacuum. In order to secure slices of the softened coal, it must be held together by means of nitrocelluloses. The best and least explosive of these is Schering's Celloidin, which is for the moment practically unobtainable on account of the war. It may be replaced with some degree of success by Anthony's photographic cotton. This is a less pure nitrocellulose and gives results which are less satisfactory. The dehydrated and air-free coal is transferred into a 2 per cent. solution of nitrocellulose in absolute alcohol and ordinary ether (of good quality). Absolute methyl alcohol gives better results than ethyl alcohol and is sold by the Bausch & Lomb Optical Company under the commercial name of Synthol. The material is secured in a strong bottle by means of a good cork wired in and remains for a day in a bath kept at the temperature of 70° Centigrade. It is allowed to cool and then transferred to a 4 per cent. solution of nitrocellulose in the medium indicated above. A second twenty-four hours in the heat brings it to a 6 per cent. solution. After the latter treatment it is enclosed in an air-tight chamber made from large diameter steam pipe. The corks are removed from the bottles preliminarily and by means of a valve in the cap of the chamber

and an automobile pump, pressure is raised to two hundred or more pounds. The coal remains under these conditions over night and has then become thoroughly infiltrated with the solution of nitrocellulose. The next step is to transfer it to a thick solution of nitrocellulose. In this it is placed again in the warm bath and after a time still further thickening is brought about by the addition of dry fragments of nitrocellulose. After several days of repeated thickening the specimens are now ready for the final process. This consists in transferring them from the thick nitrocellulose to chloroform. Chloroform has the valuable property of at once hardening the nitrocellulose and further softening the coal. After a stay of some hours in chloroform, which must not be used sparingly, the pieces of coal are transferred to a mixture of equal parts of alcohol and glycerine, where they may remain indefinitely, until needed for sectioning.

The fragments of coal treated in the manner described above are clamped in a heavy sliding microtome (the Jung-Thoma modified to the author's design answers very well for this purpose). A very sharp and heavy knife is employed for sectioning and its edge must be kept moistened with ordinary strong alcohol. The sections are turned back on the knife, as they are sliced, by means of a large camel's hair brush, wet with alcohol. Successful sections must usually be five micromillimeters or thinner. If the processes have been successfully carried out, abundant and consecutive slices can easily be secured, showing every feature of organization of the coal.

After the sections are cut they are dehydrated by means of absolute alcohol, to which a quantity of chloroform has been added to obviate the softening of the nitrocellulose in the coal. From the absolute alcohol and chloroform they are transferred to benzole or some other clearing medium and are then mounted in hard Canada balsam, dissolved in benzole or whatever clearing agent has been used on the sections. Where too high a degree of clearing is undesirable, as for example in the case of oil shales, chloroform may with advantage replace benzole or xylol. After the covers are put on, the preparations are allowed to dry for a day in a horizontal position and they are gradually warmed up with lead weights on the covers to promote flattening. When the balsam has become so thickened by the heat as to set in the cold, the slides are cleaned up. Where it is necessary to make photomicrograms of them, they are still further flattened by means of a clip clothes' pin acting on a disk of cork (over the cover) in the heat of a warm bath. For photographic reproduction, the best lenses (Zeiss apochromatics) are desirable and these should be used with a yellow screen and chromatic plates. Screens of other colors, although theoretically more desirable than yellow, have not been found practically to give as good results, probably on account of the difference between the visual and chemical focus even in the best microscopic lenses. The largest possible amount of light should be used, an end to be attained both by having a powerful electric arc as a source of illumination and the diaphragm of the sub-stage condensor opened to the widest possible degree, consistent with sharp focussing of the object. Naturally only the very best lenses will give good results under these conditions. The details of photomicrography are so familiar to all scientific workers in the field here described, that further details will only add unduly to the length of this article.

In conclusion are added, at the editor's request, some statements in regard to the bearing of the results obtained by the technical manipulations described upon the problem of the mode of formation of coal. It is to be noted that the mass of expert opinion at the present time regards coal as of the nature of modified peat and as having originated in most cases on wet land as the result of the rooting, flourishing and falling of successive generations of plants on the prostrate remains of their ancestors. This condition is realized in the cold, temperate regions of our earth. In the tropics,

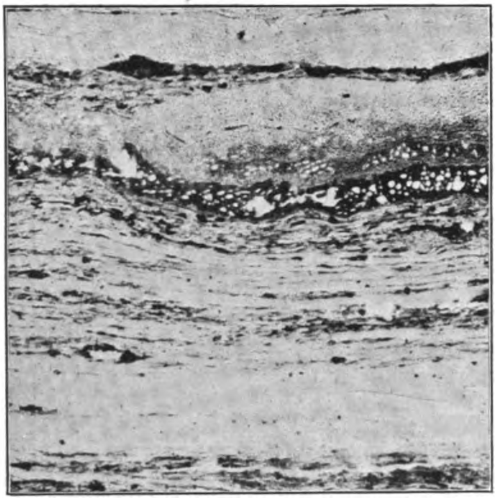


FIG. 5. Bituminous Coal from Illinois, showing gray woody bands and darker ones like cannel. Through the center runs a mass of charred wood ("Mother of Coal")

FIG. 6. Bituminous Coal, Hocking Valley, Ohio, showing longitudinal section of almost perfectly preserved charred wood ("Mother of Coal")

however, in spite of a luxuriance of vegetation, with which that of the greatest coal age (Carboniferous) has been frequently compared, there are no accumulations of vegetable matter on the soil. In warm climates the hoarding of plant remains occurs only in the bottoms of lakes and tranquil estuaries, since the high temperature makes the destruction of dead vegetable matter on land particularly rapid. Even in this country, which, as a whole, is neither particularly hot nor especially cold, we have the authority of the United States' Bureau of Mines (Peat Investigations) for the statement that by far the greater accumulations of vegetable matter occur under open water, which by its relatively constant level, safeguards the hoardings in its depths from the ravages of destroying fungi, since these are unable to flourish subaqueously.

The investigation of coals from all parts of the world and from every geological age, by the methods described in the earlier paragraphs, has made it clear that, in general, coal is of the nature of impure cannel. It is universally conceded that cannel coals, oil shales and similar combustibles, which constitute a small proportion of coals mined, were laid down in open water. We can best picture their mode of deposition by reference to a lake of today. Generally in the month of June the forest trees shed their fertilizing dust (pollen) in the air, to be borne by the winds to the waiting seeds. Most of the blossom dust is spilled, however, on the bosoms of lakes, lying in sheltered hollows, where the air currents losing their driving force drop their load of pollen, which falls on the waters as so-called "sulphur showers." After floating for awhile in circling windrows, the pollen sinks with other coarser vegetable matter into the depths of the lake or estuary. Where the pollen or spores were relatively abundant in the depths of the coal lakes of the past the result was a deposit which later became a cannel or oil shale. In more troubled and shallower waters a greater amount of the vegetative parts of plants accumulated with the spores and pollen, to constitute the raw material of a "fat" bituminous coal. Where the vegetative parts predominated a "lean" type of coal is the final result. Often in addition to spores

we find in coal wood with structure preserved, most inappropriately designated "Mother of Coal." This constituent, which is the record of ancient forest fires, frequently retains its organization so perfectly that it is possible to diagnose the type of tree from which it was derived. If the wood was only partially charred by the action of heat, its persistence as such in coal is correspondingly incomplete. Sections of coal ordinarily reveal two sorts of material showing recognizable structure: namely, "Mother of Coal" (relatively rare) and spores or pollen of the higher or vascular plants (more or less abundant). In addition to these structurally preserved constituents, combustible minerals are largely formed of a brown matrix resulting from the modification in the course of ages of the uncharred woody and other gross vegetable remains. With the fundamental brown of highly modified wood, the spores contrast by their golden yellow hue and "Mother of Coal" by its intense black (shading into brown in those portions incompletely charred). The mass of the coal has been subjected to enormous compression during the ages elapsed since its deposition in the bottom of the waters. As a consequence even its structural constituents are greatly flattened in the plane of the horizontal bedding or lamination.

The study of ultimate organization now rendered possible by improved technique appears to finally set at rest the controversy which has lasted for nearly a century and a half, in regard to the origin of combustible minerals. The generally accepted view of the way in which coal has been formed is that it is essentially, dynamically and chemically transformed peat. This conception which took its origin with von Beroldingen in the eighteenth century, has had its main defenders in Germany and as a result of the Teutonic scientific hegemony in modern times has been widely adopted in all parts of the world. In contrast to this hypothesis is the more logical view, cherished mainly in France, that coal is the consequence of organic sedimentation in open water. This opinion has been ably defended by Renault, Grand'Eury and many others, and there appears now no doubt that it is the correct one, since all the data derived from the microscopic study of coal, which must apparently ever be most cogent, are entirely in its favor. We must accordingly regard the hoardings of past plant life, preserved for us in the form of the various coals and their products, petroleum and natural gas, as having accumulated not in peat bogs but at the bottom of tranquil lakes, not *in situ*, but as the result of water transports.

BOTANICAL DEPARTMENT, HARVARD UNIVERSITY.
February, 1916.

CRYSTAL-MODELLING

A CURIOUS SYSTEM FOR CRYSTAL BUILDING BY WHICH NOT ONLY EXISTING FORMS, BUT ALSO NEW ONES MAY BE PRODUCED

BY EFFIE FRAATS CONNOR

I HEREWITH submit for scientific inspection a scale, or nest of solids, composed of five fundamental crystal forms, built of one-inch clay cubes.

This scale has taken its place in my mind with the music and color scales, proceeding, as these do, from the simple to the complex and from unity to diversity.

The science of crystal-building owes its existence to that ancient and mysterious structure, the Great Egyptian Pyramid; for it was while examining an article on the Pyramid in the *Science Conspectus* for February, 1913, that I conceived the idea of building its ideal form out of cubes. Having accordingly procured a quantity of modelling clay, I set to work.

After some weeks of the blindest experiment, I succeeded in constructing a perfect pyramid out of one-inch clay cubes, many of the n divided to conform to its surface.

Perceiving that I had built one-half of one of the five regular solids, I completed it, and fell to speculating upon the possibility of building the four remaining solids in like manner.

This effort occupied all my spare time for about two years; indeed, so difficult was the tracing of the form of the cube in the individual solids, and the consequent relations of the forms to one another, that I frequently forgot the combinations already secured and had to begin all over again. The result, however, justified the time expended; for before me appeared, finally, a great cube, with eight one-inch cubes, or units of construction, on each edge—five hundred and twelve cubes in all. By removing a certain number of these cubes, I found underneath the six surfaces of the 512-unit cube, the twenty triangular faces of the icosahedron,—that is, of the crystal form that most nearly coincides with it; for the fact that six opposite edges of this form are a trifle longer than the remaining edges, classifies it as a crystal and not as a regular solid.

The removal of a few more cubes from the icosahedron—which stands upon an edge—brings to light the twelve-faced pentagonal dodecahedron, or rather, the crystal form that very nearly coincides with it. This solid also stands upon an edge, but its edges cross the edges of the icosahedron at right angles, and each of its twenty corners lies directly in the center of one of the twenty faces of the icosahedron.

Within the dodecahedron is to be found the double pyramid, or octahedron. This has its twelve edges lying across the dodecahedron's twelve faces, and its corners lying in the middle of six of the dodecahedron's edges.

In this and the remaining cases, the crystal forms and regular solids coincide.

Within the double pyramid is enclosed an eight-unit cube, or hexahedron, with its eight corners marking the exact center of each of the eight faces of the double pyramid, and its twelve edges lying at right angles across the twelve edges of the double pyramid.

The eight-unit cube incloses the tetrahedron, its six edges lying diagonally across the six faces of the cube.

Reversing the operation, the six edges of the triangular "tetrahedron" expand into the six square faces of the cube; the eight corners of the cube expand into the eight triangular faces of the octahedron, the twelve edges of the octahedron expand into the twelve five-sided faces of the dodecahedron, and the twenty corners of the dodecahedron expand into the twenty triangular faces of the icosahedron; so that the final solid, which may

be inclosed in a 512-unit cube, is a great nest of solids.

It is not to be inferred that I suppose these five fundamental crystal forms to have been built by Nature out of cubes; they are built out of their solutions by the addition to their surfaces of minute particles. But that their ideal forms are constructed with reference to the cube, I do believe; and at any point of their growth the cubic relations are constant—the size of the unit-cube varying, however, with every step of their growth.

"The universe was built in order, and to us have been entrusted the will and the skill to discern that order."

This bit of wisdom has been handed down from generation to generation among scientists, but to most of us the universe continues to present a chaotic aspect. The ear, from the beginning, is greeted with a medley of sounds, until someone, by the simple expedient of measuring vibrations, produces a musical scale with its harmonies, and so enables us to trace variety back to unity.

Unrelated colors, too, surround and confuse us, until the prism separates a beam of light into its constituent colors and reveals among them a rigid order, also dependent upon vibrations, with harmonies as exquisite as those of music.

The vibratory sources of unity, order and harmony in the realms of sound and light, however, must be seen with the eye of the imagination; and with many of us that eye is not very keen. But in the preceding series of crystal forms, unified and brought into an orderly relation by the cube as unit of measurement, it is otherwise; for here is possible a protracted contemplation of the concrete representation of relations,—which contemplation is necessary in order to modify the *brain* sufficiently to enable the *mind* to grasp those relations. And when once the mind has been furnished with a model of the method of adjustment in the material universe, chaos is at an end; all departments yield to that magic key, and unity, order and harmony spring into being in whatever direction one turns.

This was the idea of Froebel, the founder of the kindergarten, who received his inspiration and his basic law while working among crystals. He called his law the law of the "Connection of Opposites," or Unity, and declared that without a knowledge of it his educational system was valueless. It is said by his biographers that he spent much time in trying to reduce the bewildering variety of crystal forms to one fundamental form—"presumably the cube."

Having become interested in crystal forms, and finding the text-books rather complex in arrangement and difficult to follow, I devised for my own use an entirely new system of classification. By using the series I have discovered as a basis, I am able to produce, by variation and combination, nearly if not quite all the forms that exist, to say nothing of inventing a few new ones.

The tetrahedron may be called the germ of the cube, as its six edges lie diagonally across the faces of every cube that exists.

My first step toward variety was in the manipulation of the corners, edges and faces of the cube. Extending these changes to the other members of the series, I found myself surrounded by diversity indeed, with all the "twinning" and combinations still to come.

I concluded that there should be a crystal with six-sided faces, and found by experiment that in order to inclose space such faces must necessarily include squares. I made the crystal, and when I looked for it, I found it in the text-book.

I am not at present able to determine whether the minerals of which these crystals are the indices have been brought into a more orderly relation by the classification upon which I have stumbled. But I should think this might be a subject of very great interest.

I believe the most important part of my education to have been accomplished during my experiments with crystal forms. I have noted my increasing love for symmetry and beauty of form, and can safely say that I derive as much satisfaction from the contemplation of crystals

as from music, or flower-hues or sunset tints.

I have also been forced to conclude that to become interested in anything whatever involves a process of brain-modelling, which in turn is dependent upon a protracted contemplation of the thing in question. And I have come to believe that a truly developed mind is a mind that can perceive complex relationships. Furthermore, this I *know:* in order to grasp a subject of a certain degree of complexity, the mind itself must have reached the same degree of complexity of development as the subject. I have conducted many experiments along this line—some of them in rather high educational walks—so that I am sure.

If I were a trifle more interested in benefiting humanity, I would, with these things in mind, endeavor to introduce crystal-modelling into our school system. The children of the kindergarten are already modelling cubes. It would be well to continue this good work in the primary schools, as no small difficulty is experienced in the division of clay into equal portions, the modelling of these portions into eight-unit cubes, the dividing of the eight-unit cubes into unit-cubes, and the perfecting of the same. This difficulty is owing to lack of perception and judgment, and of coördination between hand and eye—all of which are unquestionably stimulated and exercised by the clay work.

The grammar-school could go on with the modelling of the tetrahedron, and the high-school might be able to grasp the complex relations of the hexahedron and octahedron; but the remaining two forms would probably require the skill and judgment of the college mind.

To puzzle-lovers, and those to whom solitaire, and the like, have become irksome, the modelling of cubes offers a new and attractive occupation; an occupation that while it diverts the mind, not only disciplines it by the formation of new brain centers but also encourages industry and perseverance, and leads to method, order and system in dealing with the ordinary affairs of life.

Most of us have the minds of children because we have not been given an opportunity to develop and strengthen our capacity properly to relate things. When we hear one side of a story, we do not demand to hear the other side before coming to a judgment; we do not look forward to the effect of the cause we set in motion—nor do we trace the effect back to the cause, and so, in future, avoid or cultivate that cause. We do not classify or organize our mental contents, and so we soon lose our memory or experience difficulty in producing from our mental chaos what we would like to use.

Clay may be procured from any good kindergarten supply store in the form of flour. It requires to be moistened and worked into the right consistency with the hands. Experience only can instruct in this operation, but one should strive not to add too much water. After being used, it should be placed in a thick, damp cloth in a close vessel, so that it will not dry out. When it is in just the right condition the cubes will cohere in whatever position placed, and I know of no other substance that will do this.

When ready, the clay should be divided into equal portions that will make a cube two inches on each edge—that is, an eight-unit cube. After a number of these cubes have been made, they should be divided into one-inch cubes, and these cubes perfected.

Molds are not used, nor should the operation be performed by pressing the clay into shape with the fingers—except in the beginning in order to get the general form of the cube. It should, instead, be lifted and tapped lightly, with regularity and precision, upon a smooth board or any convenient surface, each of the six faces in turn, until a perfect cube emerges.

The following figures give exact directions which, if carefully followed, will produce the five fundamental crystal forms, graduated in size and related into a scale or nest of solids.

(*See cuts on following pages*)

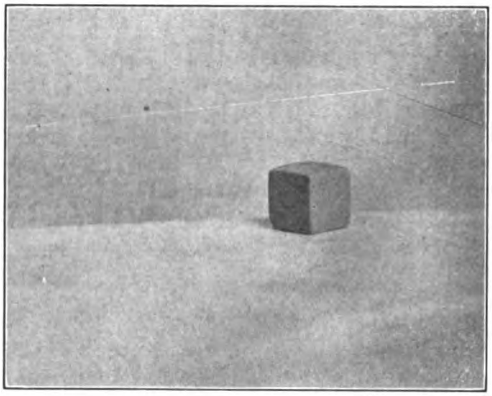


FIG. 1. The one-inch cube, or unit of construction

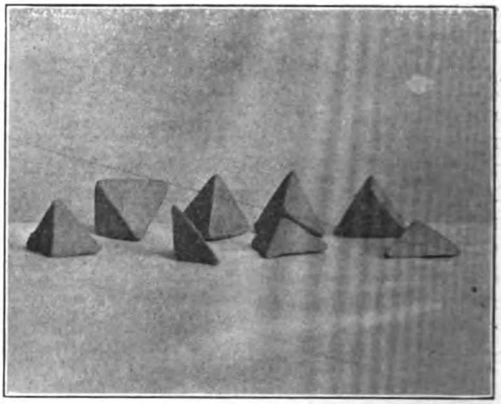


FIG. 2. Elements of the tetrahedron: four unit-cubes, each having had three corners removed; and three of these removed corners

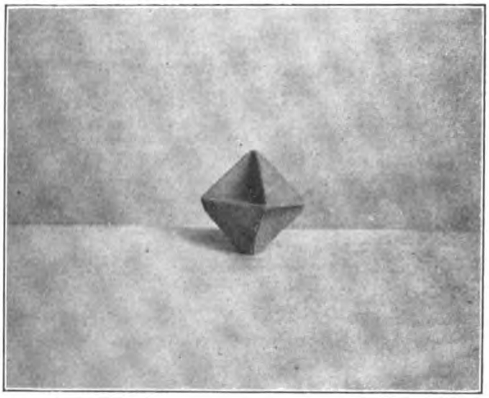


FIG. 3. First step in the construction of the tetrahedron: the placing into position of four cube-corners

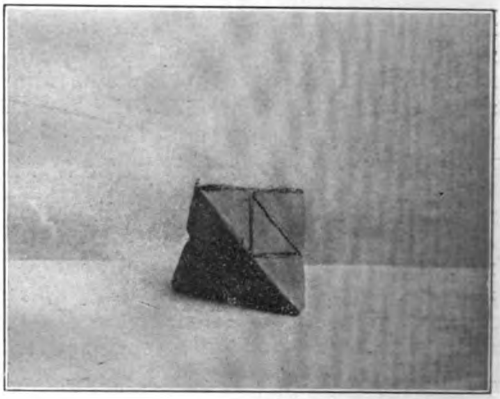


FIG. 4. The completion of the tetrahedron by the addition of the four remaining elements

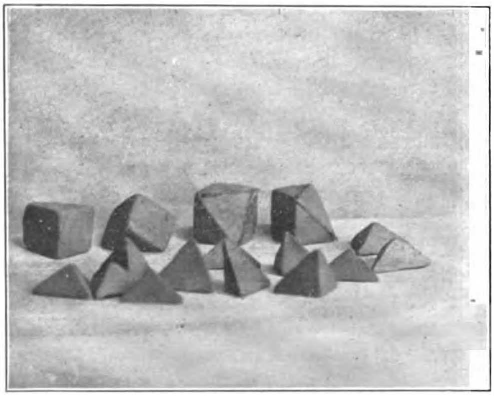


FIG. 5. The twelve cube-corners, and four unit-cubes each minus one corner, which are required to build the eight-unit cube upon the tetrahedron

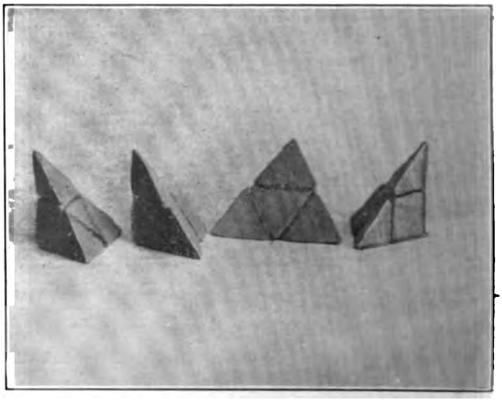


FIG. 6. The construction of four complex cube corners out of the elements of Fig. 5

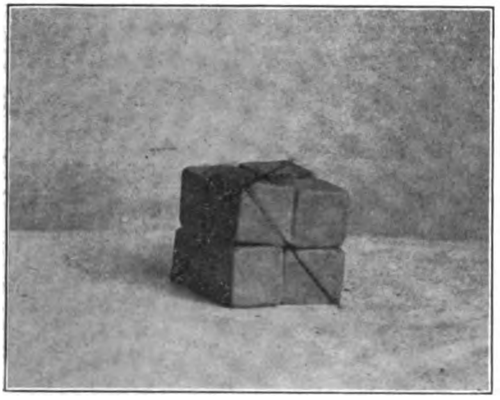


FIG. 7. The addition of these four complex corners to the tetrahedron, to form the eight-unit cube

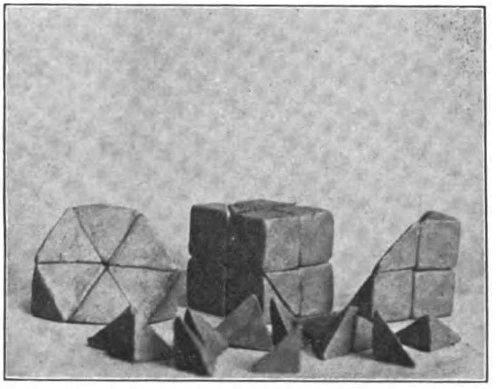


FIG. 8. The twelve cube-corners, and two eight-unit cubes each divided diagonally into halves, which are required to build the upper half of the double pyramid upon the upper half of the eight-unit cube

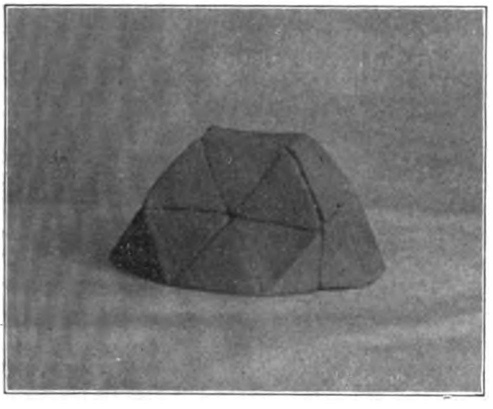


FIG. 9. First step in building the pyramid: place four eight-unit diagonal half-cubes into position

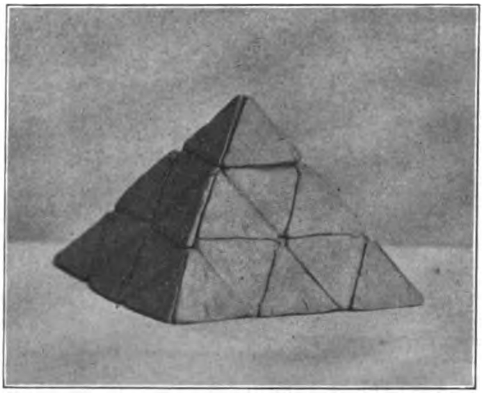


FIG. 10. Add the twelve cube-corners to complete the pyramid

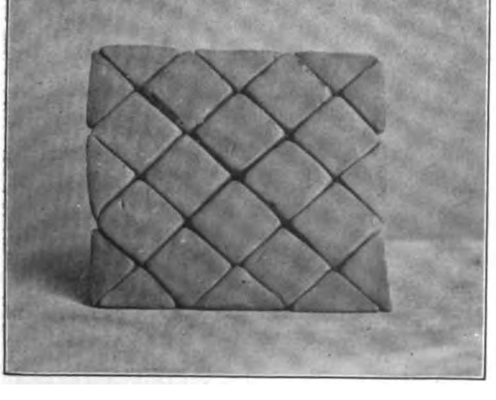


FIG. 11. View of the bottom of the pyramid (or center of the double pyramid) showing the upper half of the eight-unit cube in the center.

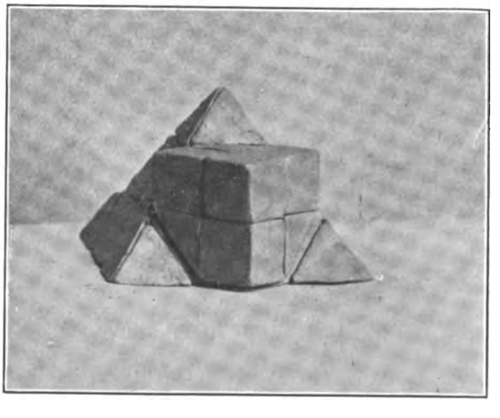


FIG. 12. First step in building the pentagonal dodecahedron upon the octahedron: place a diagonal half-cube upon each side of the pyramid

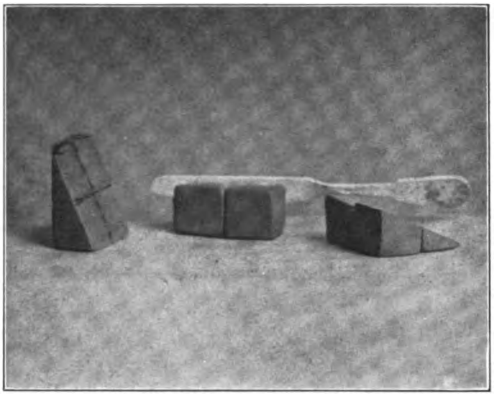


FIG. 13. Division of *two* unit-cubes to secure the additional elements required

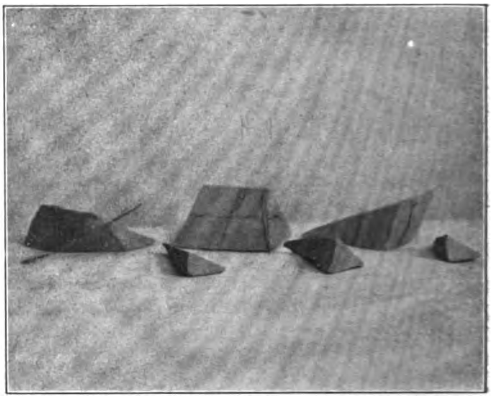


FIG. 14. Further division of the resulting sections

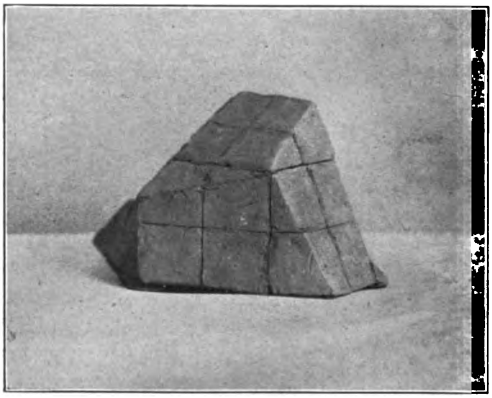


FIG. 15.* Place these three sections into position upon the diagonal half-cubes which are against the sides of the pyramid; this produces one-eighth of the pentagonal dodecahedron, or rather, of the crystal form which approximates it. The remaining seven-eighths may be constructed in like manner. It will be noticed, however, that one-half of the divisions of two diagonal half-cubes, must be "left-handed": otherwise the perplexed modeler will find that the two halves of the form will not *go together!* When properly adjusted, the surface of each eighth will contain the halves of three of the five-sided faces of the dodecahedron. When the solid is completed, these half-faces unite to form the twelve complete five-sided faces of the dodecahedron

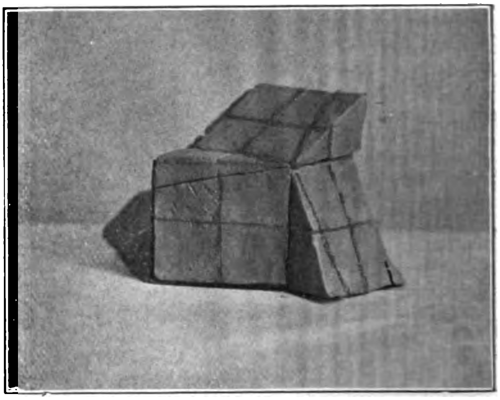


FIG. 16.* First step in building the icosahedron upon the dodecahedron: replace the sections that were cut from the diagonal halves of *two* unit-cubes

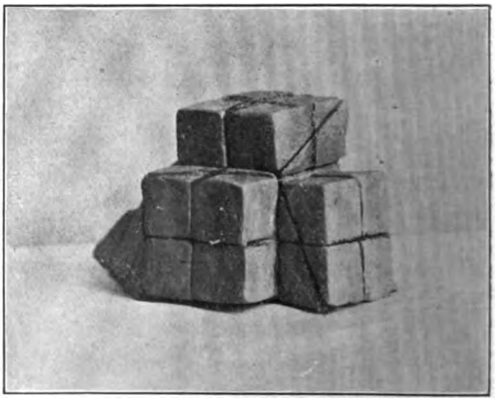


FIG. 17.* Second step in building the icosahedron: replace the diagonal halves of the three sets of two unit-cubes

* Small pyramidal projection at left is erroneous

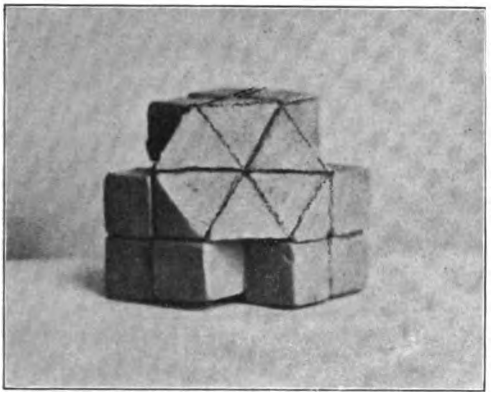


FIG. 18. Third step in building the icosahedron: remove and place into position the three inner unit-cube corners

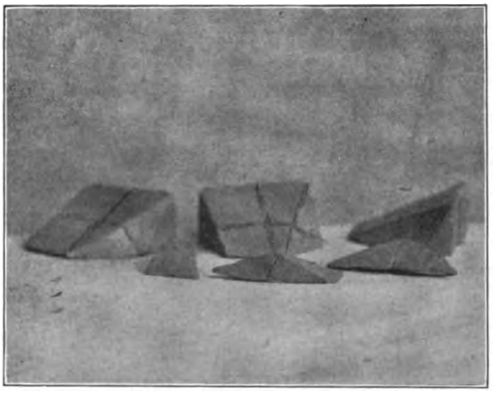


FIG. 19. New division of the diagonal halves of two unit-cubes, to secure the new elements required in building the icosahedron

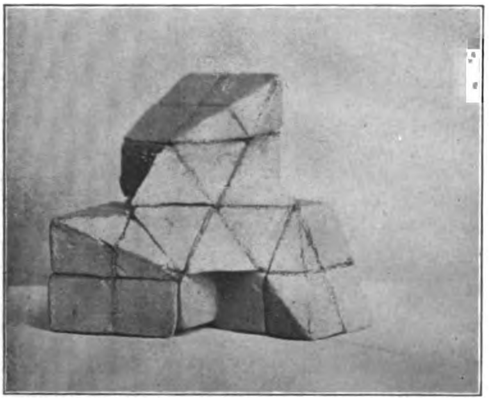


FIG. 20. Fourth step in building the icosahedron: place in position three of these new elements

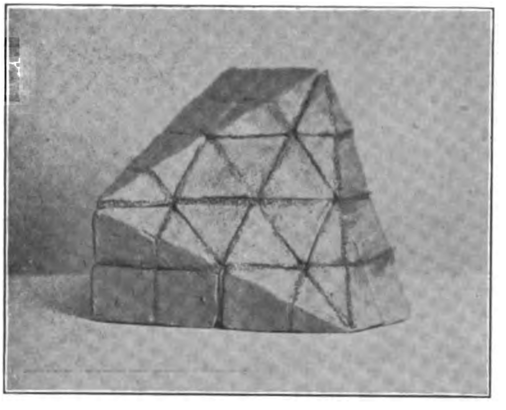


FIG. 21. Fifth step in building the icosahedron: place in position three additional half-sections, which produces one-eighth of the icosahedron—or of its crystalline near-equivalent. It will be noticed that each eighth contains one of the twenty triangular faces of the icosahedron, and three half-triangles. When the remaining seven-eighths are added, these half-triangles unite to form the required whole triangles

Here again some of the sections of the diagonal divisions of two unit-cubes require a left-handed cut

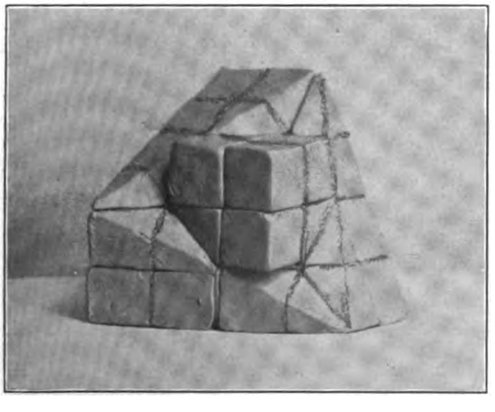


FIG. 22. Restoration to the eighth-icosahedron of the diagonal half of an eighth-unit cube

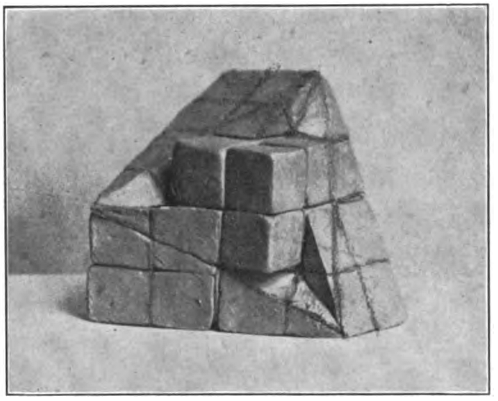


FIG. 23. Restoration of the removed section from three sets of *two* diagonal half-cubes

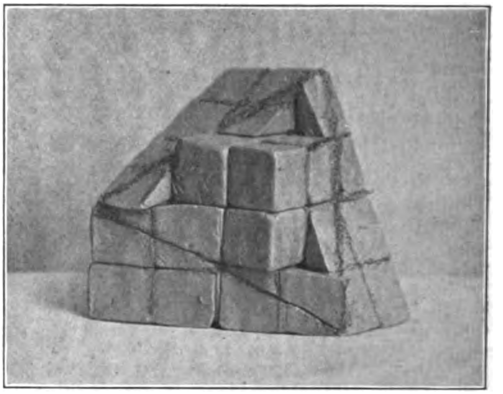


FIG. 24. Restoration of the three remaining diagonal sections of two half-cubes

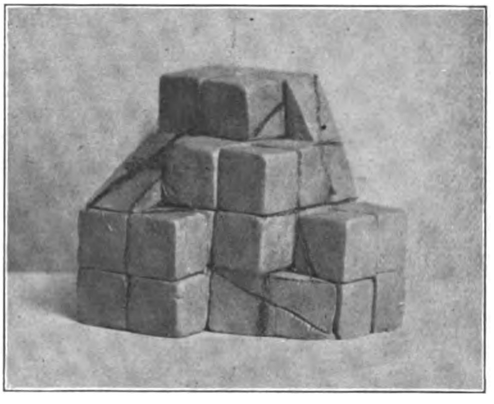


FIG. 25. Rebuilding of the double sets of two unit cubes that were diagonally divided

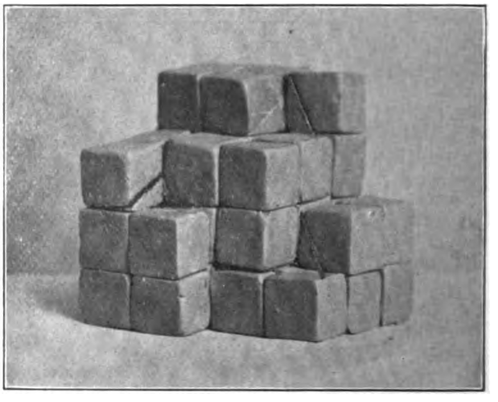
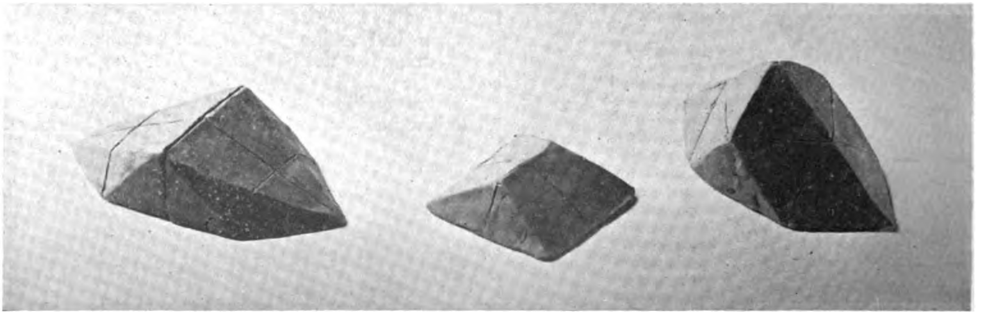


FIG. 26. Addition of the three final sets of the diagonal halves of *two* unit-cubes

It is now plainly to be seen how to add unit-cubes in order to produce one-eighth of the great final cube having eight unit-cubes on each edge; which contains the whole nest of solids



c b a

FIG. 27. Six "a" forms, applied to each of the faces of an eight-unit cube, will produce the octahedron
Six "b" forms, applied to each of the faces of an eight-unit cube, will produce the pentagonal dodecahedron
Six "c" forms, applied to each of the faces of an eight-unit cube, will produce the icosahedron
These applications must be conducted by Froebel's "Law of Opposites"

Science Conspectus

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VOL. VI 1916 No. 4

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

SCIENCE CONSPECTUS

VOL. VI 1916 NO. 5

SZECHUEN, CHINA'S WESTERN PROVINCE

THE PEOPLE, INDUSTRIES AND LIFE OF THIS LITTLE-VISITED COUNTRY, WITH ITS CURIOUS MINGLING OF ANCIENT CUSTOMS AND PROGRESSIVE IDEAS

BY H. K. RICHARDSON

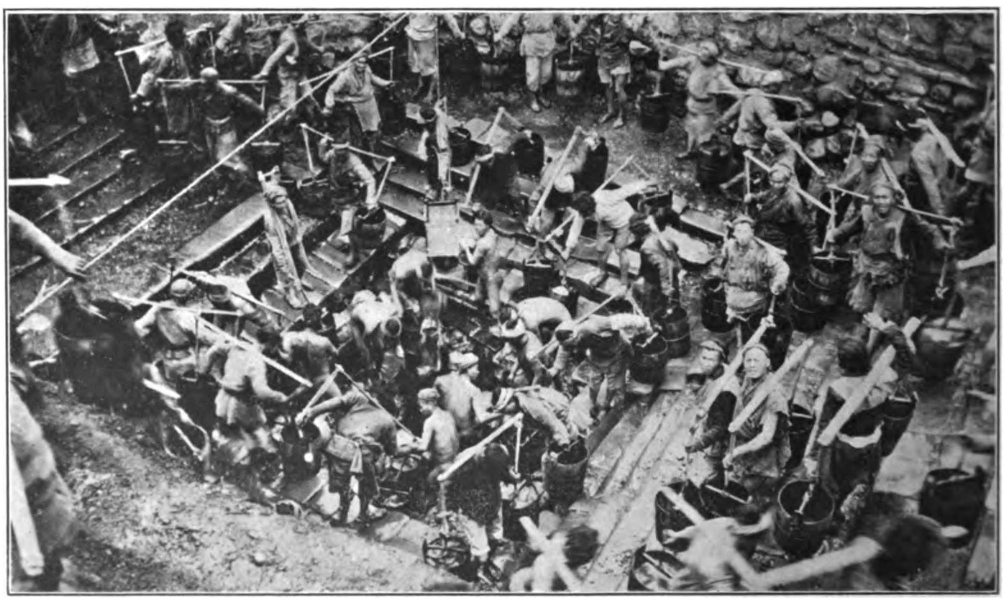
SITUATED at the most western part of China proper is the province of Szechuen, the largest, most populous and the wealthiest of the eighteen provinces of China. The province has an area of 218,533 square miles and a population estimated at 55,000,000,[1] the province thus corresponds roughly in area and population to Germany.

The name "Sze Chuen" means the "Four Rivers" the province taking its name from the fact that it serves as the watershed for four rivers which united leave the province as the Yangstze River. The province is all hills, none of which are below 2,000 feet and some on the Thibetan border reaching 16,000 feet above sea level. The only low land is on the river bottoms and these are narrow. The only plain of any size in the province is the Chengtu plain about forty miles wide by seventy miles long situated near the centre of the province. This plain is 2,500 feet above sea level at the northern end and 1,600 feet above on the southern side, and is the seat of the most wonderfully successful irrigation system that the world has ever seen. This plain is surrounded on all sides by mountains. Along the foot of the mountains on the western border of the plain flows the Min River one of the tributaries of the Yangstze. Originally this river watered only its own little valley and was a wild uncontrollable torrent in summer. About 200 B.C. two Chinese, Li Ping and his son Li Ri Ping conceived the idea of making this river water the whole plain. To this end they cut a gorge in the northern barrier mountain at the city of Kwan Hsien and made an artificial branch to the river. This branch they led across the northern side of the plain and subdivided into many smaller streams, these smaller streams are inter-connected with ditches until the whole plain is interlaced with canals and ditches, distributing the water by gravity to practically every acre of the plain. These ditches and small rivers converge near the southwestern corner of the plain and the unused water rejoins the main stream at Chiang Koand passes on down the Min River to the Yangstze. As an illustration of the foresight and thoroughness of the two engineers, they had two large iron bars weighing 1,500 pounds apiece placed in the bottom of the river at the point where the artificial river leaves the main river. Tradition has it that Li Ping left instructions that each year the river bed must be cleaned out until these bars were reached or there would be dan-

[1] This is an average based on several widely varying estimates.

Eroded river bank, Yangstze River Gorges

Looking into Bamboo Suspension Bridge, Kwan Hsien Sze

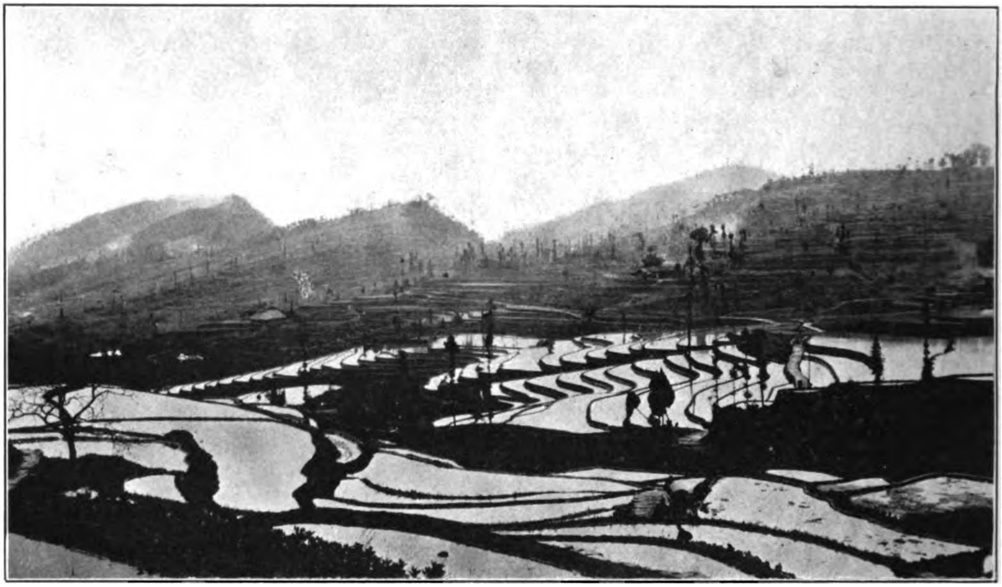


Bottom of the well. Salt Spring on river bank. Kwei Chow Fu. The supply was running low so every one was hustling to get more than his share. The men on bottom step are naked and pour into the carrier's buckets

ger of flood the next summer. At the present time contractors must clean the river until these bars are laid bare or the officials will refuse to pass the work. One of the present bars dates from A.D. 1576 and the other from A.D. 1865. For the control of the whole system Li Ping left the six character motto which is translated "Keep the channels deep and the banks low," pretty good engineering advice for B.C. 200 or A.D. 1916. Since the completion of this irrigation system there is no recorded famine nor serious lean year among the inhabitants of the plain and the plain not only supports its own 3,000,000 people but supplies rice to much of the surrounding mountainous country. Due to the abundant supply of water and the warm climate, never freezing and nearly a hundred Fahrenheit in summer, the plain is a veritable evergreen garden the year around. A view from the Kwan Hsien Hills out over the plain on a clear day as the rice fields grow yellow among the bamboo-surrounded farmhouses is a sight never to be forgotten.

It is recorded in the history of the province that in the latter days of the Ming dynasty (A.D. 1650), a serious rebellion broke out in this province against the rulers. The Mings, powerless to cope with the trouble, called upon the Manchus to help them. The rebellion was put down with such destruction of life and property that a census taken in A.D. 1710 gave the total population of the province as 144,154. To this day big mounds called "The 10,000 people's graves" are pointed out to one as a memory of what happened at that time. The big province could not be left desolate so the Manchus had recourse to forced emigration from the other provinces to Szechuen. Today it is hard to get a Chinese to acknowledge Szechuen as his native province, to the question as to how long he has lived in Szechuen you will get the startling answer, "over two hundred years" which interpreted in the light of the history given above means that his ancestors came from one of the other provinces at the time of the forced emigration early in the Manchu dynasty. This mingling of the people from so many of the different provinces has tended to make a more progressive and independent type of Chinese than is met with on the coast. It is rather surprising to some people in view of the poor communications that Szechuen has with the rest of China to find the most naturally progressive Chinese so far in the interior, but the little history given illuminates the reason.

Scattered along the western edge of Szechuen, hemmed in on all sides by the Chinese are remnants of the tribes from whom the Chinese took the country when they came to Asia. These aboriginal tribes while nominally subject to Chinese authority preserve at the centre of their section all the old tribal authority and have their own kings. Only the fringes and a few of the weaker tribes are under complete Chinese control. Unless the tribesmen break out and raid the Chinese community they are left much to themselves. There are several races of these aborigines, the most important are the Lolo in the south and the Hsi Fan in the north. The territory of these two races borders on Thibet and has been little explored by white men, in fact to attempt to pass through one section of Lolodom is almost certain death, for Chinese or foreigner. There is a striking resemblance between these tribesmen and the American Indian in both color and figure. The men are tall, magnificent specimens of humanity while the women are short, slender and less bronzed than the men. The various races dress in a coarse cloth like gunny sacks, but the different tribes are easily distinguishable by the cut and color of the clothes. Some missionary work is being carried on with success among the Miao tribe on the Yunnan border. This tribe is under subjection to the Chinese and are treated as inferiors, they feel their degraded position so keenly that they welcome the hope that Christianity brings them. No census has ever been



Terraced hillsides. Rice fields. Water standing in field. Stair-case farms

taken of these people but they cannot be far from 2,000,000 in number.

Like all parts of China the most important work of the Szechuenese is the growing of foodstuffs. In Szechuen rice is the standard and basic crop. Wheat is grown in large areas but is of far less importance than the rice. The diet of the average coolie is steamed rice, green vegetable and bean curd. A little pork once a month will be all the meat the family will have. The vegetable is prepared by first frying in lard or a vegetable oil obtained from the seed of a species of cabbage plant, then adding water and boiling the whole to the consistency of stew. Salt and red pepper are used as seasoning. The bean curd is made by grinding up beans and water to a paste, then settling out the curd with a solution of gypsum. The curd after separation from the refuse is molded into bricks which when cold are cut into convenient sizes and either boiled in the vegetable or smoked over the coals. The curd is greyish in color and about the consistency of new cheese. Variety in the diet is obtained by a variation in the kind of green vegetable used, and vegetables are fresh at all times of the year.

The Chinese eating habits are different from ours, for each person is supplied with an individual rice bowl, while the soup, vegetable and meat are placed in common bowls in the center of the table and everyone reaches for what he wants with his own chopsticks. The wealthy families follow the same general habits of diet, except that they have more meat.

On the Chengtu plain there are three crops a year, two main crops and a crop of small vegetables. The spring crop is planted in November and harvested in April. About half of this crop is wheat but hemp, ramie, the oil plant, tobacco or beans are planted in special localities. The summer crop is always rice. It is transplanted to the plowed fields as soon as possible after the spring crop has been harvested, but not later than the middle of April. The crop is cultivated twice at intervals of fifteen days, the water being run off only during the time of the cultivation. In the latter part of August the water is run off the fields so that the ground will harden and the grain stand erect. Early the first week in September all the fields will have been reaped. After this some farmers will get a crop of radish or other

Raising water from one field to another by chain pump. Dragon bone lift. Note main road on top of the terrace (the stone slabs)

small vegetable from the ground in the next two months. The rental of the land is paid from the rice crop, usually sixty per cent. of the hulled rice is the price. The spring crop and small vegetables belong to the tenant. A first class piece of land will give 160 bushels of rice per acre, or about 6,400 pounds of shelled rice.

On the hillsides of the province and places not reached by the irrigation system about one-half of the fields are reserved for rice. These fields are not cultivated for a spring crop but are allowed to accumulate water during the winter rains, this insures that there will be water enough to plant at least these fields to rice in the spring. The loss of the wheat crop that might have been grown during the winter is never considered, for a shortage of rice is the serious thing and its occurrence cannot be risked.

The importance of the rice crop is better appreciated when we know that the average Chinese eats ten or eleven bushels or over 400 pounds of rice per year. The rice bill is from sixty-five to eighty per cent. of the cost of a coolie's food. The cost of food in the majority of Chinese homes is one-half the total cost of living. To guard against shortage in the rice supply and to be prepared for siege every district city has an official granary, which in a medium sized city will have a capacity of three hundred thousand bushels. In case dealers manipulate the market too much and send the price so high that there is danger of riots, the official must start selling from the oldest grain stored and hold the price down. He must replace that which was sold just as soon as the new crop is available.

The hillsides are made available for rice cultivation by the process of terracing. To keep water on the rice it is needed that the plot of ground be approximately level. To accomplish this the hillsides are cut away in steps and the little plots are built one above the other like stairs. As the soil is clay there is little need of stone except in a place where the rains wash badly. These hillsides, which are called by some staircase farms, are better called staircase gardens for there is hardly a plot that is as large as a quarter of an acre. To bring the water from the lower steps to the higher the Chinese have several very ingenious

systems, the one most commonly seen is the dragon bone lift, which resembles a chain pump. It is a kind of a wooden endless chain on which are placed wooden pieces. These pieces fit closely into an open trough, open at the top and bottom. A man standing on the axle of a notched wheel revolves it towards him, the chain is carried over the wheel and the wooden pieces enclose a little water from the bottom pool and carry it up the trough and discharge it at the top. It is slow work but time means nothing to the coolie.

Among the higher hills where rain must be depended upon for water the staple crop is corn. In these hills the land is not terraced and sometimes a farmer can be seen cultivating a field that has nearly a forty-five degree slope. The hill farmer imports rice from the plain to serve as the basis of his meal, using the corn to piece out.

All over the province there are medicinal plants found but the larger amounts collected for export come from the Thibetan borderland. Some $1,000,000 worth of these medicines pass through the customs each year. It is said that there is a larger variety of flora found in this province than in any equal area in the world.

In common with other parts of China the industrial life of Szechuen is many years behind the developments in Europe. Szechuen is now at about the same stage industrially that England reached three hundred years ago, only China reached that same stage centuries ago. It is rather startling to realize that the silk looms, houseboats, grinding apparatus and in fact nearly all the strictly Chinese things we see on the street are made today on the same pattern that they were two thousand years ago. Considering the early date at which these implements were perfected one cannot but marvel at the ingenuity shown. It has been found that the houseboats that make the trip up the Yangstze gorges are much better and safer than a modern type boat, and the hulls of the most successful steamers that make this run are now being built on the lines similar to the old houseboat.

The silk industry is one of the most important to Szechuen. The abundance of mulberry trees makes the process of feeding the worms an easy matter. Nearly every household will hatch a few worms and it is no unusual sight in the season to see the women looking at the eggs hatching in their bosoms. Like all home industries the silk industry is carried on in full view of the street. All the operations of reeling, dyeing and weaving can be seen any day on the street. Perhaps the most interesting operation to watch is the weaving, for seated on an elevated bench over the looms is a boy who pulls the pattern strings for the flowered silk while his comrade works the shuttle. It is a wonder that he makes so few wrong combinations. The loss of much of the foreign trade in silk to the Japanese has spurred the Chinese on to improve their methods so that their product will compete with the finer grade Japanese product. The government of Szechuen has established silk worm culture schools at several places in the province. Also there are one or two reeling factories under government control, where with simple wooden machinery a much better grade of raw silk is made than in the home. The apprentices in these plants learn the whole process and are given a little common school education as well so that they will be able to start small industries when they are through. The work is self-supporting as the product pays all expenses and yields a profit to the government. In addition there is one steam filiature under private management that supplies first class silk to the foreign market. To supply the needs of the province considerable of the raw silk is woven into crêpes and satins. It is estimated that about $5,000,000 worth of silk is exported yearly from the province and that a like amount is consumed locally.

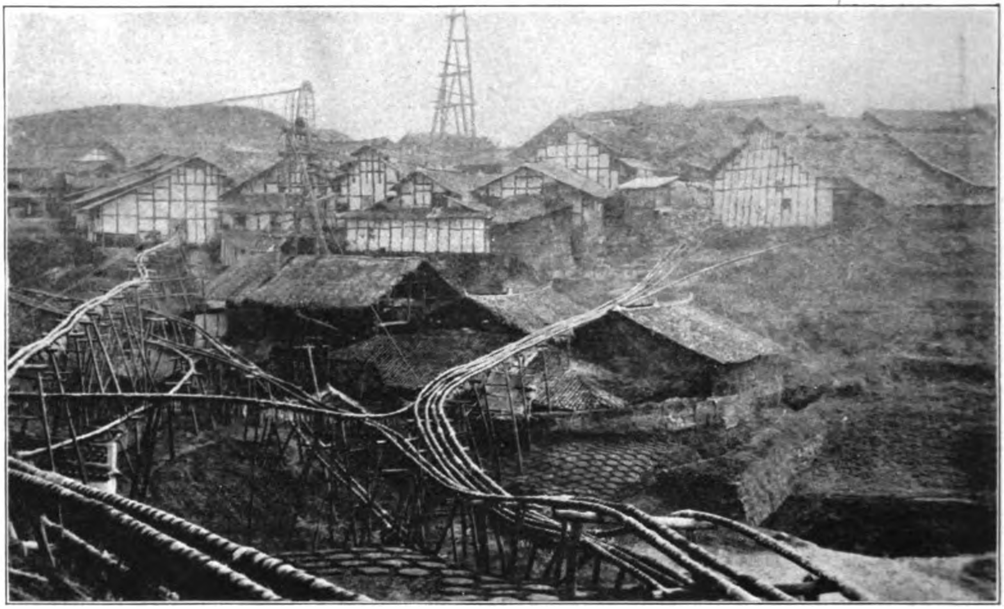
Along the river bottoms there is considerable land that is favorable to the

Coal carriers, Kwan Hsien Hills. Large load 330 pounds. Carriers get about 8 cents for a five-mile trip. Path is down through a cornfield

production of sugar cane. It is estimated that over 300,000 acres are planted to cane each year. The planting is done in February and the cutting in November. In every sugar cane section there are a number of crude juice extracting mills and evaporator houses. The crude sap is boiled down to the consistency of soft maple sugar, and sent to the refinery if white sugar is wanted, or sent to the city and sold for candy making or cooking. Most of the buyers prefer the crude sugar as the molasses it contains helps in the making of candy. Sugar sells for about six cents a pound which makes it a luxury when we think that the daily food of the ordinary man will cost only three cents.

An ordinary laborer receives six cents a day if he "eats himself" (*i. e.*, buys his own food) and must support his family on that. A skilled carpenter is extremely fortunate if he gets ten cents a day. I have hired many of the best men at $2.00 a month which was better than they could have got at other places. For this they would have worked thirty days from sunrise to sunset, with only two meal times and two recesses for smokes, if our policy had not been no Sunday work. The Chinese workman does not have a Sunday rest, his only holiday is a week at New Year, and the fifth and eighth month feast days. At these times it is the custom of Chinese employers to give a small present of half a month's wages for the three occasions to their workmen.

Of all the native industries the salt industry has brought out the best of the ingenuity of the Chinese. Salt is recovered from brine, which is obtained from the earth in three types of wells. First the open well dug some thirty feet deep to uncover a salt spring as at Kwei Chow Fu, the second where the well is driven through a bed of clay and a little stone to a depth of 1,000 feet and the third the wells driven to a depth of 4,000 feet through a soft sandstone as at Tzu Liu Tsing. In case of the first sets of wells the brine is brought up the steps of the well in buckets by coolies and transported by sluiceways to the open evaporating pans fired by coal. The water is evaporated off until a six inch layer of



Salt wells at Tzu Liu Tsing, Szechuen. Bamboo pipe lines in foreground. The houses illustrate the usual type of construction, wood with plaster panels

salt is left on the pan, when the cake is removed, broken up and sold. The culm from the coal is mixed with clay and makes a good briquette. The second type of well is found all over the province and is recognized by its fifteen foot winding drum. In these wells the brine is raised by means of a bamboo tube or bailer, put into buckets and sent to the nearby evaporator house to be made into pan salt. The motive power for the drum is human labor, a cow or a buffalo according to the section and the wealth of the farmer.

The deep wells are all situated at Tzu Liu Tsing and are the most numerous and productive in the province, if not in China. It has been estimated that over ten thousand wells have been driven in this territory, of which five thousand are in active operation today, while some few hundred are still in the drilling stage. The territory is very hilly and comprises three market towns under the government of two separate districts. All the wells are within an area of fifteen by three miles. The town supports a population estimated at one million, who think, dream and live by salt. The existence of this large city is not suspected by one outside of Szechuen. Every day in the year one can see a stream of coolies carrying salt away by every road, while boat loads are leaving continuously for down the river. Over 200,000 tons of salt are officially known to leave the town per year and the salt office fails to get a large amount that is smuggled away. One thousand tons a day would not be far from the daily production of these wells, which is a large industry for China. In all the wells the brine is brought to the surface in long bamboo tubes, 110 feet long, and sent by way of bamboo pipe lines to the natural gas wells to be evaporated. The pipe lines are operated by gravity and the idea has been in use for over a thousand years. The business hustle of this town, the noise of the many derricks, the sight of the pipe lines and the sky line of derricks make one think of a thriving oil well district in United States and not of China. The salt wells have made more millionaires

than any other thing in Szechuen, and Tzu Liu Tsing is the home of them all.

Szechuen is the home of the remarkable ch'i tree, the tree from which the wonderful Chinese lacquer is obtained. From the sap of this tree the Chinese make a varnish or lacquer that dries on a wet hot day to a beautiful gloss surface. It will not scar if hot boiling water or hot dishes are placed on it. It is used on all table tops because it does not scratch easily.

Most of the China wood oil now so much used in varnish in the United States comes from this province. The nuts from which the oil is expressed are rid of the fleshy exterior, ground shells and all, then heated slightly and the oil expressed in a crude wedge press. The oil is transported in woven bamboo baskets lined with paper, to the collecting depot, where it is sent to Hankow for trans-shipment to United States. The government is encouraging the planting of these trees, as all the nuts now obtained are from trees that sprung up of themselves.

A description of Szechuen is incomplete without a word or two about Chengtu, the capital of the province. The capital is situated in the centre of the Chengtu plain and is usually approached along the east road. The city itself is planted full of trees and bamboos and cannot be seen or distinguished until the very walls are reached. These walls dating from the time of the early Manchu dynasty, A. D. 1680, are made of brick upon a sandstone foundation backed by an earthern embankment some thirty feet deep. The walls are thirty-five feet high and twelve miles in circumference, and are paved with brick on the top of the earthern embankment, making a fine promenade. The walls are pierced by four gates outside of which are four suburbs built along the roads leading to the gates. The suburb along the east road is five miles long and looks like a continuous town the whole length. Outside the city on the plain wheelbarrows are used to transport coke, pigs, manure and passengers. Sometimes it is a mixed load but more often the passenger has a seat fixed in front of the high middle wheel.

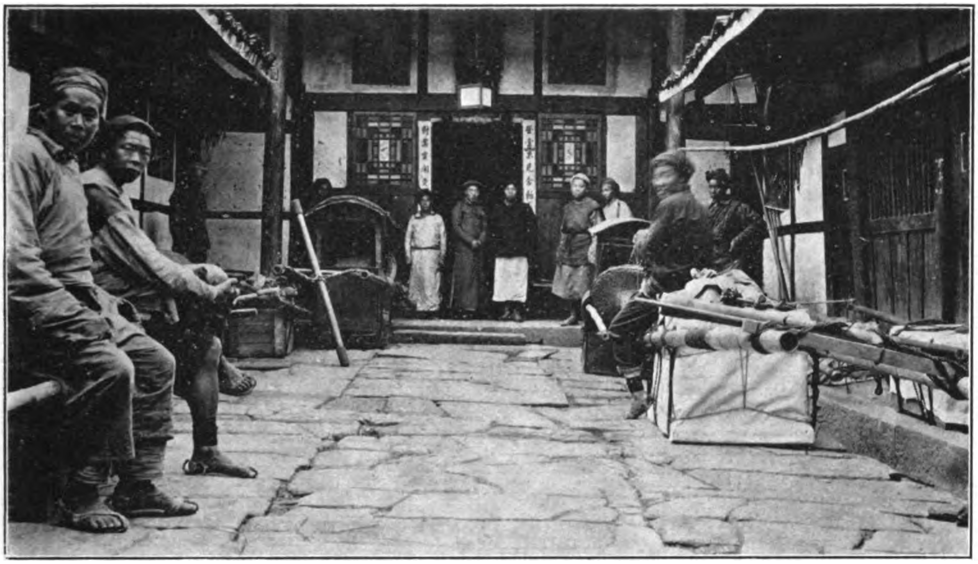
Entering the city the first time, a foreigner is asked by the police at the gates for his card, what his business is to be in the town, how long he expects to stay and how many pieces of luggage he has; this over he passes into the city and his baggage is passed along as it arrives. Not so fortunate is the native, for before he can enter he must have every box opened and examined. Likin or duty is charged on things innumerable and as every city is a law unto itself one can imagine the inconvenience caused a Chinese who does much traveling, in fact no one but a Chinese would have the patience to submit to such treatment.

The main street just inside the East gate is the widest and most important business street in Chengtu. Here are to be found the silk stores, stores which sell foreign things; although the Arcade a few blocks away, a covered cross street, is the headquarters for foreign goods; and most of the silversmiths. The shop signs are all hung vertically and are taken in at night so as not to be lost. In the evening after the shop fronts are put up this street is the scene of a street bazaar; many small dealers in curios, bone, baskets, socks, boxes and trinkets squat along the edges of the street in front of the shops and sell their goods by the weird light of the candles or oil lamps. Every other business except this and the tea-shops close at dark. Scattered among the other shops at convenient intervals are the cash shops or the money exchangers, a most necessary institution in these days of monetary chaos. In every-day transactions amongst the coolies the old cash or the coin with the square hole is the standard of reckoning. None of these "cash" are made today but to facilitate matters the provincial government has coined brass pieces that represent ten, twenty, fifty and one hundred cash but which contain brass in diminishing proportion. Side by side with this brass is a silver coinage used by the government, wealthy Chinese

Nut grinder or rice huller. All the nuts for the China wood oil sent to United States are ground in this type of apparatus

and the foreigners. Between these two coinages there is an ever varying daily exchange; in two years the value of a silver dollar has varied from 1,200 to 1,700 of the small cash. Add to this the military notes with their fluctuating value and you can appreciate the question asked of a Chinese friend "Is it the monetary system of the Chinese that made them such gamblers or vice versa?" Szechuen, be it said to its credit, has the simplest monetary system of any of the provinces of China.

All shop fronts are open to the public and the wares exposed to inspection, so one can tell at a glance what the shop has to offer. Most of the stores are of a standard size, one section, twelve feet wide by fourteen feet deep. Behind the store room is a room for the family with perhaps a loft above for the apprentices to sleep. Including the shop the usual family will have about six persons in a space fourteen by twenty feet and all the family activities will go on here. The shops are built tight up to each other, in country, or city, so that light and air only come in the shop front and the back door, if there is one. At night the only air that can get into the rooms is that which leaks in through the cracks, so the prevalence of consumption is easily explained. These crowded quarters naturally force many of the family activities into public view. It is a common sight to see the family eating their meals, the youthful members of the family being disciplined, the children being nursed, or the family quarreling right in public view. If any repairs are needed in the house the carpenter and the mason will do their work on the street, all passers-by good-naturedly move around the mud-pile of the mason and the wood of the carpenter even though they take up half the width of a twelve-foot street. The lack of house room is a nuisance when one of the family dies and it is necesssary to have a funeral feast and rites over the dead one. The difficulty is solved by extending a temporary platform out into the street in front of the shop about eight feet and surrounding it by mats. It makes little difference to the family that they have reduced the street to its lowest dimensions



Court yard of the "Great Prosperity Inn" Kuan Yuin Chiso, Szechuen. (H. K. R.'s carriers and baggage in the yard ready for the night)

and traffic moves as over a single track railroad. These little matters of inconvenience are overlooked by the good-natured Chinese for it is the custom to do so.

All the streets in the city and the principle country roads are paved with stone slabs. The streets in Chengtu are kept tolerably clean and the city has the reputation for having the cleanest and widest streets of any real Chinese city except Peking, in the republic.

Passing along the street in a sedan chair you will sometimes find yourself set over the goods in a shop. Looking ahead you will see a big box taking up nearly the whole street slowly approaching. As it comes nearer you will discover that there is a man under the load which is strapped to his back. As he slowly waddles down the street everything and body must turn aside so he can have the whole street. These men can carry a whole parlor suite at once and one load will move a coolie family, cupboards and all. In the mountains, they carry 350 pounds about twenty miles a day.

All the little shops seen along the street are built on the front edge of the lot of land belonging to a wealthy Chinese. Behind these shops he builds his "gung gwan," a house built around two or three courtyards and back away from the street. In the rear will be a garden, a rookery or a pond. The whole lot will be surrounded by a compound wall ten feet high and eighteen inches thick which keeps him and his family secluded from the neighbors. It is the custom of every Chinese family to keep their girls in seclusion from the age of twelve until they are married at from sixteen to twenty, although some are "sent out" (married) at fourteen or fifteen. The compound wall helps in making this seclusion possible. This seclusion of unmarried girls is one of the reasons why there is so little immorality in a purely Chinese city. It is a rare thing for a Chinese girl to go astray for she is watched so closely. All the prostitutes are slave girls bought in their youth from poor parents and brought up into the life.

Foreigners living in interior cities live in compounds like the wealthy Chinese

and the interior can be arranged to be as much foreign as is wished, only when one goes on the street would he know he were in China, for the seclusion of the compound wall is well nigh complete.

Perhaps some one will wish to take the trip to Chengtu as a summer vacation trip; it will be one of the rarest treats he has ever had. Leaving Shanghai, the first stage, 600 miles up the broad and muddy Lower Yangstze to Hankow the Chicago of China, is made in some of the finest river steamers in the world. Changing here to smaller and lighter draught steamers the journey is continued 400 miles up to Ichang the end of all-the-year-steam navigation. This picturesque city of 50,000 inhabitants with its pyramid mountain and its horde of up-river junks will have been reached in ten days if all has been well. From here the best way to see the famous Gorges is to take a houseboat. Slowly being pulled up this wonderland of Nature one gets full chance to absorb the grandeur of this beautiful stretch. (The houseboat averages one mile an hour.) During the low water season (winter) a houseboat will cover this stretch from Ichang to Chungking about 450 miles in approximately a month depending upon the strength of the down river winds encountered. In the summer high water a steamer will make this trip in five days with several exciting times while passing the rapids. Arriving at Chungking sedan chairs are ordered for the 350 mile overland trip to the capital (Chengtu), coolies engaged, food boxes packed and off we go. The road is marked off in regular stages of about thirty miles each, and each night we put our bed up in a Chinese inn at the end of the stage, taking it down again the next morning. Every morning six o'clock finds the men starting, so we go on to the first village where the men stop for their rice before breakfast. At night the inn is reached, food prepared, all the loads counted to see that none have strayed off during the day and we are soon asleep and ready for the next day. Traveling so close to the country as one does on this kind of a trip, every day has its surprises and to one of an investigating mind thirty miles a day seems too fast to absorb all the new things seen. After ten days our journey comes to an end and we find ourselves welcoming the foreign house at the end of the line. The trip of 1,800 miles (Shanghai to Chengtu) has taken us six to eight weeks and we return richer in knowledge, with a better appreciation of the backward condition of interior China, marveling at the ingenuity shown at the earlier age and with sympathies broadened and outlook enlarged.

THUNDER AT SEA

Captain Ault, sailing master of the *Carnegie*, a non-magnetic ship under the direction of the Carnegie Department of Terrestrial Magnetism, has been investigating the audibility of thunder at sea, during the course of the voyage from Alaska to New Zealand from August 6 to November 2, 1915.

Lightning storms or displays were seen on twenty-two different occasions, but they were accompanied by thunder on only six occasions. In these six cases the distance of the nearest land was from fifty to six hundred miles. In all cases, however, where streak lightning was seen, thunder was also heard. The other cases were sheet lightning. It has been suggested that the frequent inaudibility of thunder at sea may be due to the fact that the sound of the thunder is drowned in the noises on shipboard during a storm. The *Carnegie*, however, observed lightning without thunder several times in calm weather. In one case in which several claps of thunder were heard, the successive intervals between flash and clap showed that the storm became inaudible when its distance exceeded five miles from the ship. The observations will be continued during the remainder of the present cruise of the *Carnegie*.

DEVELOPMENT OF COMMERCIAL DIRIGIBLES

REASONS WHY THE COMMERCIAL DIRIGIBLE IS A SERIOUS POSSIBILITY AND SOME OF THE WAYS IN WHICH IT CAN BE USED TO ADVANCE CIVILIZATION

BY RAYMOND B. PRICE

TO ANYONE who has the opportunity to see what England is doing in the aëronautical field, it becomes clear that she intends to dominate the air just as she today dominates the sea. She is literally building aëroplanes by the thousand and dirigibles by the hundred. Her interest in dirigibles is not confined to any one type, but she is pursuing the problem with open mind and evidently intends to learn all that can be learned relating to the lighter than air mechanisms. Nowhere in France could I discover any great interest in the future of the dirigible and even those actually engaged in the industry saw for it only a moderate usefulness as a naval auxiliary with no promise whatever for commercial service. While England's vision of the usefulness of the dirigible is undoubtedly largely inspired by the vital importance of her naval protection and the established value of dirigibles for submarine hunting and coast and naval scouting in general, yet it seems likely that the impetus given to the development of the dirigible for these reasons will expand into a determined effort to make such craft so useful for commercial purposes as to help sustain the burden of supporting a considerable military dirigible establishment. One of our leading naval authorities has recently stated that if we in America possessed complete designs for a zeppelin and with every detail of information regarding its construction and assembling, it would still take two years before we could produce a serviceable zeppelin. Nor must we overlook the fact that it took Count Zeppelin ten years to find out most of the unsuspected dangers arising from imperfections in design and construction and operating dangers that thorough scientific foresight could not provide against nor even in some cases foresee. To the uninitiated it must have come as a great surprise to read of the difficulties and complications which Santos Dumont experienced in developing his early dirigibles. For what reason we do not know, it is only since the war started that zeppelins have been so shaped as to take advantage of the more recent knowledge relating to stream line shape, decreased resistance, and similar factors. Presumably the need for maximum speed even at some sacrifice of lifting power has been emphasized by military developments. Probably the zeppelin today stands forth as the world's foremost product involving the most recent scientific knowledge possessed by mankind. Within the past four months a British engineer officer about to attend a test of one of the latest British rigid dirigibles expressed the fear that she would break her back. It is thus evident that the development of such machines is yet absolutely in its infancy and we have no more right today to conclude that such craft will not in the course of a few years be of extreme commercial value than we have to say that no further progress will be made in engineering, chemistry, physics and education.

It is impossible, in a short paper, to enumerate the scientific problems involved in the construction of even a small dirigible, but it is safe to say that the most complete and up-to-date knowledge of the various sciences involved will be none too effective in meeting the problems of construction and operation, not only for military purposes, but perhaps to an even greater degree for successful commercial operation.

The commercial problem, however, has several elements to distinguish it from the military problem. Until there are aërodromes, repair shops and persons skilled in the handling and repair of dirigibles near almost every community where dirigibles are likely to be used, it is not to be expected that any considerable number of dirigibles could be in service. In spite of the great increase of meteorological knowledge, there will always perhaps be danger of such craft being swept from their courses by unexpected storms, and adequate places of refuge with trained assistants, day and night, must be provided before a general use of dirigibles can be successful. This involves, in addition, aërial charting of courses, development of comprehensive day and night signal systems and the necessary skill in using them. To a considerable extent, the aëroplane problem has corresponding needs and undoubtedly the development of the aëroplane will be sufficiently rapid to force provision of some such facilities for air navigation in the near future.

The expense of operation and maintenance is of minor importance for military purposes, but of paramount consideration for commerce. The bags of most of the balloons that have been used in the past have been constructed of silk, cotton, linen, or other fabric either oiled or coated with rubber. In all such cases, the permeability has been fairly high so that the loss of gas has been a serious item. This loss is generally increased with age owing to leakage resulting from deterioration and strains from mechanical handling. The commercial problem, therefore, must consider decreasing permeability and improving mechanical construction of the gas bag, as well as decreasing the cost of the gas. Until recently, when, either because of change of altitude or change of temperature, the gas expanded, it was necessary to relieve the pressure by releasing gas which was wasted. The modern zeppelin practice is to compress any surplus gas and keep it in containers so that it can be again used when needed. The construction of the zeppelin which provides an air space between the outer covering and the inner ballonets by minimizing changes of temperature, likewise reduces such losses. This intermediate air space, however, introduced a new danger because gas which had escaped from the ballonets became mixed with air and gradually assumed explosive proportions. Only recently has this danger been eliminated by ventilation of the intermediate air space. It has been suggested that this improvement has again permitted the use of anti-aircraft guns on top of zeppelins, although only a couple of years ago their use in that position was discontinued because of some danger not disclosed to the public.

It is obvious that every advance in concentration of strength and energy, every bit of progress in reducing weight without sacrifice of other qualities, brings nearer the day of the commercial dirigible. It has sometimes been reported that the passenger carrying zeppelins familiar to many Americans in Germany prior to the war were commercially profitable. It is doubtful, however, whether this would be correct without making allowance for government help of one kind or another. Perhaps enough has been said in this rather rambling outline to indicate that the commercial development of dirigibles must depend absolutely upon coöperation of a very far-reaching type. Those who are familiar with the work of the Automobile Chamber of Commerce and the Society of Automobile Engineers realize that the lesson they have taught the country is one which must be taught in general, not only for our commercial and industrial welfare, but for the very safety of the nation, and the coöperation which will be necessary to make quick progress in the commercial development of dirigibles should be far more comprehensive than anything that the automobile industry has yet experienced. Suppose, for example, that our national executives should decide that it is a matter of importance for the nation to have dirigibles developed rapidly so that their commercial and hence their military efficiency could be quickly made use of,

it would not seem impossible to organize a development committee, for want of a better name, somewhat along the following lines:

Members from:

(a) Government. Scientific experts from naval and military departments, Smithsonian Institution, Bureau of Standards, Post Office, Coast Survey, Coast Guard, Council of National Defense, National Research Committee, government laboratory recommended by Naval Consulting Board, Weather Bureau.

(b) Scientific organizations. Societies and individuals, colleges and technical schools, geographical and exploration societies, associations of doctors and lawyers.

(c) Industries. Metal manufacturers, engineering firms, textile and wood-working concerns, rubber and other industries based upon colloids, scientific instrument makers, chemical industries, motor manufacturers.

(d) Commercial bodies. Chamber of Commerce of the United States, merchants' associations, distributors of light expensive merchandise, real estate boards.

(e) Transportation interests.

(f) Sporting and publicity bodies. Automobile and aëro clubs, hunting and traveling associations. Navy League, National Security League, and patriotic organizations, Advertising Clubs of the World.

(a) The importance of government initiative in this matter cannot be overestimated. While every other important nation in the world is concentrating all of its resources and forces, without exception, under government leadership, our government on the contrary tends to evade its responsibilities. This is a very serious matter, worthy of the careful study of every thinking American, because it is today an open question whether forty-eight loosely united, almost independent, states, without strong federal government leadership, can compete successfully with other industrial nations, compact and coördinated. It seems especially important by every means possible to urge our government to show leadership especially in those departments where the necessary ability and organization already exist. Therefore, a small committee representing the best brains and optimism of our naval, military, post office and other government departments would be not only a tremendous help, but the psychological effect on the other groups would be decisive. Dirigibles might readily connect with steamers well out at sea and take mail to or from inland cities, thus saving not hours, but days in communicating with Europe and other continents. Many other federal functions are involved.

(b) The importance of refining everything from motors to fabrics down to small fractions of 1 per cent, involves the most comprehensive use of all of our scientific brains and resources. As many legal questions will arise as air navigation increases, even the lawyers can do their part. It has been stated that airships have caused remarkable cures of some nervous troubles. With berths, hot meals, electric light and electric heating, already possessed by zeppelins it is not beyond the limits of possibility to consider aërial sanitaria. The whole effect of air travel upon man must be studied.

(c) The astonishing increase of knowledge of the properties of alloys in the past few years leads us to expect still more important discoveries in this field in the near future. The combined resources of our steel and other metal plants, with their highly efficient chemical and physical laboratories, the coöperation of engineering firms, the more scientific investigation of textile methods and products, the better methods of testing and evaluating both wood and metal constructions, all lead to expectation of great progress in those directions. It is known that materials exist which are one hundred times less permeable to hydrogen gas than is rubber as now used, so great possibilities lie ahead through coöperation of the experts and applying the resources of the colloidal industries.

(d) The Chamber of Commerce of the United States, with its national affiliations and interests, could well number among

its activities the furthering of dirigible development. Everything which tends to facilitate communication between localities tends to the advancement of the nation. There are large quantities of comparatively light but expensive merchandise which perhaps even today would stand the expense of aërial transportation. The obtaining of ground for hangars and repair plants and for flying fields will test the abilities and enthusiasms of our real estate boards, as well as our local chambers of commerce and other associations.

(e) As feeders for railways in sparsely settled communities or in locations where railroad building is extremely difficult or expensive, as means for carrying mails and light merchandise in similar country, even as competitor for the automobile where roads are scarce or forests and other obstructions control, in many ways it is conceivable that the dirigible could be placed at the service of mankind.

(f) We have passed from the bicycle to the automobile and now are passing from the automobile to the aëroplane, and from the aëroplane to the dirigible is but a short step. This does not mean that any of these mechanisms are losing in usefulness, but on the contrary, each is filling a larger and clearer field of its own. Exploration, traveling for pleasure, even hunting can be carried on by air with marked advantage.

It may seem to some that the end is not worth the means, that the aëroplane will do all that the dirigible can and that the difficulties in the way of developing the dirigible commercially do not warrant the effort. On the other hand, the dirigible has inherent advantages not possessed by the aëroplane. It is quite conceivable that the future will witness a combination of the advantages of dirigible and aëroplane in some compromise craft which will depend partly upon the aëroplane wing and partly upon the gas bag. Such a craft might have less speed and consequently be easier to land. It would have greater bulk and thus be an easier prey to wind and storm than the aëroplane, but it is evident that in one type of craft neither all of the advantages nor all of the disadvantages can be combined. Already the dirigible makes valuable use of planes and the little British "blimp" instead of a car has beneath its gas bag an aëroplane fusilage, so that it can slide along the ground somewhat as an aëroplane can. It is said to cost France today $5,000 to train every aviator. This could scarcely be considered a commercial proposition, though, of course, this figure is the result of war hazards, war pressure and the necessity for war speeds and constructions. It is necessary to keep a clear vision between the exigencies of war and commerce, although each is closely related to the other and progress in one must result from progress in the other.

It is entirely conceivable that our cities of the future will be built with flat roofs, all of a level, with the streets covered over with glass so that either aëroplanes or dirigibles could land on the roofs, and those residents of suburbs a hundred miles distant could land from their air machines directly over their offices in a minimum of time. This might involve the elimination of chimneys by means of forced draught or preferably by the production of power in central plants or at the coal mines and the distribution of heat, light and power electrically, which many of our best experts in this field have already promised us for the comparatively near future.

Whether or not the dirigible becomes of commercial value, probably depends more upon the United States than any other country. Whether this achievement is recorded to our credit or not may depend upon the national imagination, optimism and determination. The military and naval development of the dirigible is inevitable, but it may require the vision, courage, bigmindedness and generous coöperation of all of the agencies which have been enumerated and many others to achieve the real possibilities of the dirigible, at any rate, within the lifetime of most of us. Let us hope that the Council of National Defense may see the vision and be given the power to be the moving factor in realizing this great benefit to mankind.

THE INTERNAL SECRETIONS

CHEMICAL FACTORS IN THE REGULATION OF THE ORGANISM —AN EXPANDING DEPARTMENT OF PRESENT-DAY BIOLOGY

BY PERCY G. STILES

ONE need not be a profound student of science to appreciate that the coördination of activities is a most striking fact of animal life. What happens in one place is adapted to what is occurring at another. It may fairly be claimed that each part acts more distinctly for the good of the whole than for its own advantage. Clearly, this could not be the case if there were not some mode of transmitting influences from organ to organ.

When one considers the possible means of such transmission the nervous system is at once suggested. This wonderful structure is so fashioned that, conceivably, any part of the body may definitely affect any other. It is in this respect like a telephone exchange which affords to each subscriber the opportunity to communicate with any other. The nervous system has long been looked upon as the essential instrument of coördination. A second possibility has lately become unexpectedly prominent. It is the transmission of chemically active products through the medium of the circulation.

Such products of the tissues are usually called internal seçretions. A compound added to the blood by one organ will, within a minute, be quite uniformly diffused over the whole body. There is no way to limit its distribution and bring it all to bear upon a restricted portion of the system. In this respect the interchange of influences by means of internal secretions lack the refinement and precision which characterize the nervous correlation. We have to do with a set of drugs which, like those administered by the physician, must be offered to all the tissues—to those which seem indifferent as well as to those which are evidently responsive.

The internal secretions have proved to be more numerous and more important than anyone would have predicted fifty years ago. The subject will doubtless occupy a larger and larger place in future expositions of physiology. A brief summary of the matter as it now appears may be attempted. The part played by these chemical messengers can conveniently be stated under three headings.

I. *Internal Secretions and Growth.* Normal development cannot be accomplished unless the blood receives certain contributions from several small organs. One of these is the thyroid in the neck. If this fails to play its part the growth of the child is arrested. Nor is the result a simple dwarfing of stature; the proportions and features are grotesque and the mental retardation parallels the physical. The proof that this condition (cretinism) depends on thyroid failure is satisfactory: the mingling of dried thyroid substance from animals with the food of the cretin gives a marvelous impulse to its development. The treatment, fully continued, may nearly counteract the defect.

Another organ, which radiates a well marked influence upon growth, is the pituitary body, an inconspicuous appendage upon the under surface of the brain. Its action may be perverted by disease with the result that there is overgrowth, tending toward the gigantic. In other cases of pituitary disorder there may be malformation of the bones. The effect on the configuration of the face may be startlingly uncouth. Even in adult life these changes may set in.

The thymus, a mass of tissue high up in the chest, is believed to regulate growth in some obscure fashion. Much more distinct are the relations which exist

between the reproductive organs and development. The dependence of a symmetrical type upon the normality of these organs is familar. It should remind us that any group of cells may have more than one function; in this case the dispensing of internal secretions reacting upon the individual goes along with the preparation of the germs of the coming generation.

II. *Internal Secretions and Maintenance.* The thyroid and the pituitary body which so profoundly affect the course of growth continue to exert a regulation upon the processes of mature life. Loss of the thyroid by an adult leads to a serious depression of health with physical signs recalling cretinism. Loss of the pituitary—if we may judge from the case of the lower animals—cannot be survived.

At least two other organs make contributions to the blood which cannot be spared for any length of time, the pancreas and the adrenal bodies. The pancreas was long known to elaborate an important digestive juice. But it is like the organs of reproduction in that it does not merely separate something from the blood but adds something to it. Removal of the pancreas without doubt impairs the digestive capacity but this result is overshadowed by another: all the tissues lose the power to oxidize, and so to profit by, their chief fuel which is sugar. This loss is the central fact in diabetes. When developed to its limit the power to use fat is also abolished and the problem of nutrition becomes hopeless.

At the back of the abdominal cavity, above the kidneys, are the paired structures known as the adrenal bodies. Insignificant as they appear they are vital organs, the removal of which is followed swiftly by prostration and death. Something must go out from them which gives tone and efficiency to more than one system. When the adrenals are gradually wasted by disease the failure of strength corresponds with the degree of their destruction. Their extracts do not successfully compensate for the lack of living cells; the body seems to need a slow, uniform delivery of this internal secretion and periodic dosing does not prove equivalent to the natural condition.

III. *Internal Secretions at Particular Times.* So far we have spoken as though internal secretions were set free slowly and steadily, having their effects throughout long periods. It remains possible that they may be discharged to the blood somewhat suddenly under peculiar circumstances. We have the best of evidence that the adrenals can thus be thrown into a temporary activity far beyond their ordinary performance. The particular occasion for this is one of stress and excitement. It has been clearly proved that as such times the chief product of the adrenal cells (adrenin) is increased in the blood. It has also been proved that this internal secretion confers upon an individual the utmost command of his physical resources. There is ground for the belief that the thyroid as well as the adrenal tissue has special awakenings to accelerated production.

We began by stating that one organ of the body may influence another either by nerve-impulses or by secretions carried in the blood. These two types of action admit of some combination as will now be obvious. The temporary arousing of the adrenals in emergencies is certainly due to a stimulation effected through the nervous system. The thyroid is probably under a similar nervous government. Hence, in these two cases if not in others, a reaction that is first mediated by the nervous system may be completed under the influence of internal secretions.

The medical doctrines of the Greeks centered upon the theory of the Four Humors, according to which health depended on the maintenance of right proportions among four essential ingredients of the body-fluids. It is interesting to observe that we are once more giving place to views very suggestive of the old. We believe not in four but in a considerable number of active substances which must be rightly balanced. Abnormal conditions may arise either from deficiency or from excess on the part of any one of these.

It is not long since physicians assigned their patients to groups according to "temperament," the lymphatic, the sanguine, and so on. The scientific equivalents of these designations seem to be connected with the organs of internal secretion. The diagnostician can now recognize in a peculiar type, the evidence of an over-active thyroid, in another the signs of pituitary excess. When one looks at the pictures of men suffering from serious diseases of these organs one is constantly impelled to say, "Why I have seen people who looked like that!" It is fair to suppose that for every bad case of this class there must be many mild ones. Most of these will not be recognized as pathological. As individuals can be found to suggest all types of insanity while yet keeping within the province of the sane so we can see hints of departure from the ideal balance of the internal secretions in those who are still effective members of society.

THE ICONOCLASM OF FACT

MAN'S aptitude to form rash conclusions from insufficient data and then use these conclusions as facts upon which to base subsequent statements and even philosophies is nowhere better exemplified than in the realm of geology and astronomy. Observing that from volcanoes red hot liquid rock came from within the bowels of the earth it was concluded that all of the earth's interior was molten rock. Secondly, it was argued, since the earth's surface was cold and the interior hot the earth must represent a star cooling from a gaseous through a liquid state. When sufficiently cool a crust of solid rock would form. Since then, it was argued, only a thin crust separated the earth's surface from the exceedingly hot interior during the early ages of earth history, the climate of this time must have been quite warm from the great amount of heat received from the interior. As the crust became thicker and thicker, less and less heat came from this source and consequently this uniformly warm, humid climate changed gradually during the geologic ages to a diversified one, whose zonal arrangement was finally due to the heat received from the sun, and it was only in late geologic time, in fact, just before the present, that the heat, received from the interior of the earth, had decreased sufficiently to permit the occurrence of frigid zones and glaciers.

During the last ten to twenty years this theory of gradual refrigeration has been attacked both by astronomers and geologists. One of the strongest weapons of the latter has been the discovery of evidences of glaciers practically throughout the entire geologic column. Such characteristic glacial ear-marks as till, striated pebbles, polished and grooved rock-floor over which the ice had moved, are as common far back in the earth's history as during the last great ice age in whose closing stages we are now living. A glacial period, greater than that which lately covered much of North America and Europe, scoured the lands around the Indian Ocean at the close of the Paleozoic Era, twenty million years or more ago. Just previous to the Paleozoic, before the incoming of the earliest definitely known fauna, occurred another great ice age, of whose wide area of distribution there is accumulating proof. Glacial deposits of this age are known from Europe, Asia, Africa and Australia. Finally till and striated pebbles have been found across northern Ontario for a distance of 800 miles and from latitude 46° to 50° in rocks of Lower Huronian age, which are next to the oldest rock formation known. There is evidence of glacial deposits of similar age in Scotland and possibly in China.

With this demonstration of the presence of glaciers upon the earth at practically the very beginning of geologic time the earlier theory of the very gradual refrigeration of the world's climate is proved untenable. And that this is another of man's many hypotheses based on insufficient data is further attested by the complete evidence of the alteration of glacial climates with tropical or semi-tropical climates prevailing over almost the entire earth.

H. W. S.

EVOLUTION OF SERVICE

HOW THE COMPULSORY SERVICE THAT STIMULATED LIFE AND EVOLUTIONARY PROGRESS IS BECOMING VOLUNTARY—AN ANALOGY FOR THE OPTIMIST

BY H. W. SHIMER

SERVICE is an essential to life upon this earth. Should no help be given to others, all life would cease to exist within a single generation. This service is surely compulsory in the vast majority of plants and animals, but it becomes more and more a voluntary helpfulness in the higher forms of animal life. In the following article the various kinds of service will first be defined and then their influence in the evolution of earth's life from the earliest times to the present noted.

When one animal eats another the latter performs a service for the former though it is surely a compulsory one. The total amount of suffering is, however, infinitely less than is the compulsory service of the sweat-shop worker who knows that he must slave hopelessly on until death comes as a welcome relief. To the animal all is joy until the quick sharp pang of death. J. G. Holland expresses in his "Bitter-Sweet" the universality of this form of compulsory service: he says,

"Life evermore is fed by death,
In earth and sea and sky,
And, that a rose may breathe its breath,
Something must die.

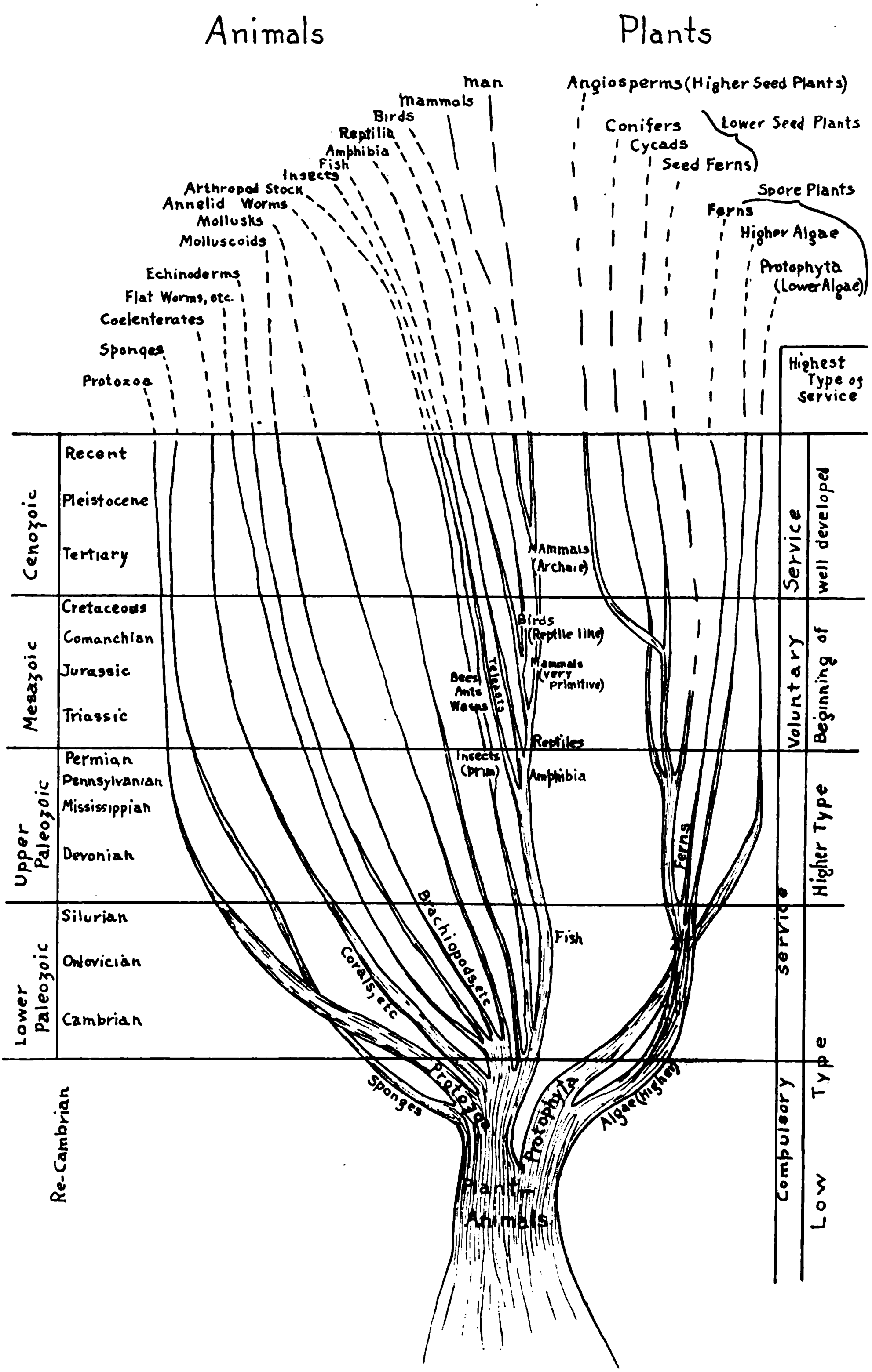
"The milk-haired heifer's life must pass
That it may fill your own,
As passed the sweet life from the grass
She fed upon."

It is to this type of service that is due all animal life and all higher forms of vegetation. That it has existed upon the earth from the early times of earth history to the present is proven not only by the fact that all animals at present live upon other organisms but that animals with teeth, claws, tentacles and other food-procuring devices occur fossil in the rocks of all those ages.

Another type of compulsory service, especially common in plants, is the yielding of the parent's life in the production of young. We see this in the majority of herbs and grains,—the radish, cabbage, wheat and oats all must give their life to produce seeds. Though this manner of producing offspring is not so characteristic of animals, yet it occurs among insects, corals, and many other groups. This type of service was likewise present from the earliest periods of earth history to the present.

A most important type of compulsory service from an evolutionary point of view is the storage of food for the developing young. This is seen typically in the yolk mass surrounding the embryo in the bird's egg and the starch nutriment enclosing the very young wheat stalk or oak tree.

The definition of voluntary service will here be somewhat broadened and be made to include the variability among individuals of the same species, or variety, in the amount and kind of labor they expend upon their young. Some birds, for example, though trembling with fright, will continue to sit upon and protect their eggs even when threatened with death; while other individuals of the same species desert their eggs or young upon the least approach of danger. Some sun-fish will fight courageously to protect their rude nests, others are very timid. In the solitary wasps, typified by ammophila, Mr. and Mrs. Peckham have shown that individuals of the same species differ


Animals
Plants
man
mammals
Birds
Reptilia
Amphibia
Fish
Insects
Arthropod Stock
Annelid Worms
Mollusks
Molluscoids
Echinoderms
Flat Worms, etc.
Coelenterates
Sponges
Protozoa
Angiosperms (Higher Seed Plants)
Conifers
Cycads
Seed Ferns
Lower Seed Plants
Spore Plants
Ferns
Higher Algae
Protophyta (Lower Algae)
Highest Type of Service
Cenozoic
Recent
Pleistocene
Tertiary
Mesozoic
Cretaceous
Comanchian
Jurassic
Triassic
Upper Paleozoic
Permian
Pennsylvanian
Mississippian
Devonian
Lower Paleozoic
Silurian
Ordovician
Cambrian
Re-Cambrian
Mammals (Archaic)
Birds (Reptile like)
Mammals (very primitive)
Bees Ants Wasps
Teleosts
Reptiles
Insects (prim)
Amphibia
Ferns
Brachiopods, etc.
Corals, etc.
Fish
Sponges
Protozoa
Protophyta
Algae (Higher)
Plant-Animals
Service well developed
Voluntary Beginning of
Higher Type
Service
Compulsory Low Type

greatly in the amount of food they furnish their young. Some are good providers, others poor. Some also are exact and precise in all their movements, others are very negligent and disorderly, leaving their offspring less effectively protected in numerous ways. This difference in the instinct of helpfulness to offspring between individuals of the same species is here called voluntary service.

As we take a bird's-eye view of the history of the earth we see that compulsory service has always been present but that it increases in effectiveness from ancient times to modern. We note too that voluntary service first appeared, minute both in kind and amount, during the medieval period of earth history and has rapidly increased in effectiveness to the present. Voluntary service occurs only in those animal groups which can respond to a high type of compulsory service. It is this additional service to offspring which enables their possessors to succeed so well in the universal competition,—this most efficient goad to evolution.

As we see from the chart the plants in existence during the pre-Cambrian and lower Paleozoic are those that multiply by spores—special cells developed by the parent to carry on the race. These spores, compared to the seeds of higher plants, stand but little chance of developing into adult plants. A few of the animals present during these early times likewise reproduced their kind by means of spores but most of the groups produced two kinds of cells, large ones called female and small ones named male; the union of two of these different kinds was necessary to produce a germ which could develop into an adult form like the parent. These reproductive elements, the male and female cells, were thrown by the parents into the water where if union happened to occur a new individual resulted, otherwise they died.

By mid and upper Paleozoic, plants and animals had become so evolved that they could furnish nutriment for the developing embryo. Among plants small seeds were present in the seed-ferns, primitive cycads and conifers. Among animals a capsule, enclosing yolk, surrounded the embryo in all the dominant classes from the mollusk to the fish, amphibian and reptile. This high type of compulsory service was already present during the lower Paleozoic, among the mollusks and arthropods, but here the amount of yolk stored was small. The surrounding tough capsule protected the developing embryo from many of its enemies while the enclosed yolk ensured sufficient food for considerable growth, so that upon leaving the capsule it would have a better chance for survival to maturity.

If we may judge by the most nearly related living forms, there must likewise have been present during the entire Paleozoic a rudimentary kind of instinct, with but a minimum amount of free choice and hence of voluntary service. Even the insects, first appearing in the upper Paleozoic and rapidly becoming so numerous in the vast coal-swamps of that time, all belonged to the lower orders with a very low degree of instinct.

With the evolution in the Mesozoic Era of the higher seed-plants, insects and fish, and of the most primitive birds and mammals, a higher type of compulsory service was initiated and a distinct beginning in voluntary service made. The higher seed-plants, typified by the oak and hickory, furnished a larger amount of embryonic nutriment and better seed protection than did the primitive seed plants of the upper Paleozoic; the nutriment was surrounded by a protecting capsule. The development of bees, ants and wasps with the mid-Mesozoic was most probably accompanied with a beginning of that wonderfully evolved instinct and of some voluntary service to their young, as well as to the members of the community, which characterize their modern representatives. The incoming at the same time of the highest order of fishes, the Teleostei, may likewise have been accompanied in some individuals, as it is in many of their living descendants, by a certain amount of voluntary service.

Some of the Mesozoic mammals, allied to the existing monotremes, probably like these laid eggs, hatched them as birds

now do and then suckled the young; while others, more nearly related to the kangaroos and insectivores were, in all probability like their modern representatives, forced to protect and nourish the embryo within the body until well developed, and after birth to continue this care by fighting off enemies and nursing the young. While all the service before birth, and much after it, was compulsory there still remained a distinct amount of voluntary service both in hatching the eggs and in feeding and protecting the offspring.

During the Cenozoic appeared the highest forms of service, both compulsory and voluntary, yet developed on the earth. The production of conspicuous flowers, of nectar and other devices for the perpetuation of species of plants is a form of compulsory service originating mostly during the Cenozoic, though undoubtedly some of these devices received their inception in the Mesozoic.

The development in the Cenozoic of the living groups of birds was accompanied, if it did not originate in the Mesozoic, with the hatching instinct. A considerable amount of this instinct is, however, voluntary service, since it differs so greatly among individuals of the same species or variety. After the young are hatched the parents are doubtless compelled by instinct to feed and protect them, but here again much of the service is without doubt voluntary. (Since the birds of the Mesozoic were reptile-like in the sharp teeth, claws upon the wings and long vertebrated tail possessed by most individuals they may also have been reptile-like in their failure to personally hatch their eggs and feed and protect the young.)

The appearance of carnivore, rodent and hoofed mammals in the lower part of the Cenozoic initiated a much higher type of voluntary service. These mammals, to judge by their nearest living relatives, were compelled to serve their young before birth by interuterine nourishment and after birth through the secretion of milk. They also protected their young as well as their mates, and procured them solid food. They were, doubtless, impelled to these latter acts by instinct but a considerable amount of voluntary service was present.

In the upper part of the Cenozoic appeared man and with him began the development of the highest type of voluntary service yet evolved upon this earth. Slowly, extremely slowly, it advanced at first and was for long doubtless limited to the family; but gradually it was extended to other members of the clan, nation, language and finally even to the barbarian, heathen or gentile, and even to lower animals and to plants. Man is, however, still under the law of compulsory service. The unborn young must still be given interuterine nourishment and the young child food and care, while public opinion and man-made laws force the laggard to duties which he is not yet sufficiently evolved to perform voluntarily.

We thus see that the development of life upon this earth was due to service, that without such service no higher forms of life could have evolved. Animals can live only through the death of other animals or of plants. Both animals and plants are compelled to give of their strength, or often life itself, in the production of young. As animals and plants became more highly evolved they developed a higher type of service, that of furnishing more nourishment and better protection to their offspring. Very gradually, side by side with the higher kinds of compulsory service, there was evolved a voluntary service; minute in kind and amount at first, it has finally come in the nobler members of mankind to dwarf the former by comparison into insignificance. Pre-Paleozoic time and the long Paleozoic Era stand for low types of compulsory service; the Mesozoic for higher kinds of compulsory service with a definite beginning of voluntary service; while during the Cenozoic this latter type increased in amount until at present in man it far over-shadows the service of compulsion.

Evolution as we see it upon this earth has thus occurred through each successively higher group taking more and more from others, especially from parents, and giving more and more in return, especially

to offspring; the service rendered is passed on, not returned. When, however, a plant or animal group takes more and more from others without giving additional service in return we have parasitism, and parasites are not now, nor were they in the distant past, in evolving lines. Parasites, whether plant, beast or human, are degenerate; the individuals become weaker and weaker and finally the line ends in death. Those who give more than they receive are thus in the advance line of evolution; they blaze the way for the others to follow. It has always been so. The advanced lines of both plants and animals must always have given a certain amount of service, even though minute, above that which they had received; otherwise these higher types of service could not have come into existence. The vast majority of plants and animals are stand-patters; they give what they receive because they must.

The trend of evolution has thus been from compulsory service to voluntary, from an enforced aid to others, to help given because of love for others.

Since the path of the past shows us the road of the future we may feel assured that future ages will see all humanity developed into the universal sympathy and loving service so characteristic of the highest types of today. Optimists have thus a solid basis for their philosophy. It is the pessimist who sees but a portion of the whole; he sees but a part of a pendulum swing, not the definite advance after the forward and backward motion.

FOSSIL BACTERIA DISCOVERED

Marvelous as were the discoveries of such pre-historic monsters as the Mammoth, the Mastodon, and the Stegosaurus, they are now eclipsed by recent investigations which show the most minute microbes and bacteria in fossil form. The ancestors of our modern infectious disease germs and microbes have been found in fossils of the earliest life on the earth. Fossil bacteria have been discovered in very ancient limestones collected by Dr. Charles D. Walcott, secretary of the Smithsonian Institution, in Gallatin County, Montana. For some time Dr. Walcott has believed that these bacteria existed, and mention of the fact was made before the Botanical Society of Washington on April 6, 1915, when attention was called to their existence in association with fossil algal deposits of the Newland limestone. The belief that bacteria were the most important factor in the deposition of these ancient limestones was also mentioned by Dr. Walcott in a preliminary publication of the Smithsonian Institution. At that time, however, no definite bacteria had been discovered, but in thin sections of limestone from the collections made in 1914 the microscope now shows these very minute forms of life, some twenty to thirty million of years old. The bacteria were discovered in three sections cut from an algal form included under the generic name Gallatinia, named after the great American explorer Gallatin. The bacteria consists of individual cells and apparent chains of cells which correspond in their physical appearance with the cells of Micrococci, a form of bacteria of today. The world has believed that bacteria were modern forms of life but now we are made to realize that they existed in the dawn of world history, many million years ago.—*Scientific American.*

"BE A SPORT"

This expression is always used to encourage experience upon the physical and passional side, the "past good" in man. The use of it as a spur to see the demonstration of a new machine, to attend a lecture, or listen to a prayer, would create laughter. Yet just as finding experiences for his mental and spiritual natures spells man's advance today, so during the early history of the race the coarser spurs of passion, of physical gratification, were necessary.

What in these older ages was a present good has today become a detriment, a hindrance to man's present evolution.

H. W. S.

EVOLUTION THROUGH CONTRASTS

THE principal effect of the cold morning sponge bath is its stimulation of all the body organs. After it man is wide-awake mentally as well as physically. He has received energy and poise which will not be followed by any bad after-effects. This is caused by the contrast between the warmth of the body and the cold water. Similarly, we in the temperate zone work better mentally in the cooler months of fall and spring, when the contrast between the cold of out-of-doors and the warm rooms stimulate us out of our natural slothfulness. If, however, the contrast is too great the effect is detrimental.

It has been shown that those areas of this globe have the most energetic, the most highly evolved peoples which are swept by frequent cyclonic storms. The contrast between the lower temperature, higher humidity and lessened atmospheric pressure during the storm and the opposite during clear weather is given as the principal cause. The difference between the lower temperature of night and the higher of day has a similar stimulating effect.

The contrast between winter and summer, cold and warmth, humid and dry atmospheres, low and high pressures, does not affect man alone but the entire organic kingdom. Its effects upon all plants and lower animals is greater than upon man himself, that is his body, for man partially creates his own environment and thus tends to obliterate the effect of some of nature's spurs. Mind, the central nervous system, not only of man but of all animals, is more sensitive and consequently more profoundly influenced by these causes than the body, and is likewise strongly affected by the passions.

Day and night, bringing a greater or less increase in the feeling of safety and fear, causes an exercise of the nervous centers, which exercise tends to their enlargement. The frequent recurrence of hunger for food and its satiation, the joy in the pursuit of food and the fear of capture, are also common to all animals, while in the higher forms anger at having their food snatched away by another or their home or loved ones attacked, leads to further stimulation of these centers, while the lengthening of memory in man increases the strength of love and frequently changes anger into hatred.

With the rapid increase in the depth and breadth of love in the higher representatives of mankind, the necessity for hatred, anger, fear, and the other lower passions has disappeared. The love of the most highly evolved as well as the least, of learning, etc., here furnishes more energy than all the passions combined; it is, too, a source of energy which does not weaken man. The mere mental entertaining of the lower passions weakens his body, as anyone can easily see, especially after the body is somewhat weakened by disease; while thoughts of affection strengthen it.

Much of mankind still needs these contrasts of fear and safety, anger, joy, etc., for the development of sufficient energy to continue evolving, and could rightly no more see the desirability of anyone overcoming the passions than the horseshoe crab the future disappearance of the mud and slime in which he takes such pleasure and from which he gets much of his food for growth and development.

In the evolution of life as we know it upon this globe, the chief external factor, aside from the sun in its rôle of heat and food provider, has been the spurs towards energy through nature's contrasts. During the earlier geologic ages, that is, before the appearance upon the earth of the higher forms of life, these spurs were mainly those which affect the body, such as hunger and its gratification, heat and

cold, light and darkness; though very early did the central nervous system add its spur in the development of energy through the feelings of fear and safety. In later geologic times, with the development of the higher forms of mollusks and arthropods, and especially with the incoming of the vertebrates, the production of this energy has been principally through the central nervous system. Anger and love, the latter rapidly increasing in the higher members of mankind, are here the principal spurs; and the lower forms of energy-making are still effective. It is the higher forms which are most efficient.

During the evolution of life, energy and evolution are thus synonymous terms, with mental energy a later and higher development than physical energy, for the amount of energy, active or in reserve, is a standard of evolution; and this energy through the ages has been derived from successively higher and higher sources. The purely physical stimuli furnished by the natural surroundings of organic life have yielded in effectiveness to the gradual growing stimuli resident in life itself, in its emotions of anger and love, and later in the push of the intellect and spirit. H. W. S.

DISCONTINUANCE OF SCIENCE CONSPECTUS

IT IS with much regret that we announce the discontinuance of SCIENCE CONSPECTUS, with this issue. The expense and effort required to publish a magazine with limited circulation and with no resources from advertising, are too great to warrant its continuance.

Although we have not been able to fully carry out our aim in founding this magazine, it has been possible to find some men of scientific attainments who have the happy faculty of making their subjects clear to lay readers, many of whom are scientists themselves in another field of endeavor, and to this extent we have fulfilled our mission.

That there is a field for such a publication covering a broader scope, perhaps, is shown by the great interest our readers have taken in SCIENCE CONSPECTUS. It is hoped that this field will sometime be covered by an ably conducted publication.

The editors are indebted to the friends who have contributed to this magazine, and also to its readers whose appreciation and encouragement have been frequently and generously expressed.

PHOTOGRAPHY OF HIGH VELOCITIES

HOW BULLETS TRAVELING 92,200 FEET A SECOND HAVE BEEN PHOTOGRAPHED—HOW HIGH SPEED PHOTOGRAPHY MAY BE USED IN RESEARCH

BY W. A. HYDE

ONE of Christian Huygens' brilliant conceptions was that a sound wave might be considered as made up of a number of elementary waves, each centered on the wave front of an instant before, as in Fig. 1. Here O is the center of disturbance and after a given interval of time the spherical wave front has reached AB. It was Huygens' theory that each point on this wave front, as a, b, c, etc., was the source of small elementary waves; by taking them sufficiently close together their bounding surface $A'B'$, called the "envelope," would be a circle slightly farther removed from O than AB. In this way the wave is assumed to travel through the air.

A striking confirmation of this is shown in Fig. 2, which is a photograph of a bullet with its attendant air waves passing through a pipe, through the sides of which slots have been cut. The photograph was taken at the Militärtechnische Akademie at Charlottenburg, under the direction of Dr. Carl Cranz, and was handed to the writer during a visit there in 1914. The bullet is traveling about 2,700 feet per second, greatly in excess of that of sound and, therefore, forms a wave of compression in the air continuously, as shown. This wave is constrained by the wall of the pipe but emerges from the apertures in the form of small waves whose centers are at these apertures. It is apparent that the envelope of these wavelets is the head wave of the bullet; analysis and synthesis are seldom so plainly combined.

An elementary diagram will make this clear (see Fig. 3). Suppose AB to be a thin rod moving to the left with a velocity V, greater than that of sound, S, in the medium. At any instant previous, A was at A', say. At that instant it was the source of a disturbance which caused a wave of compression to travel outward, till at the end of this given time interval the sound wave had traveled to C' with a velocity S, characteristic of the medium. In air this velocity is 1,100 feet per second.

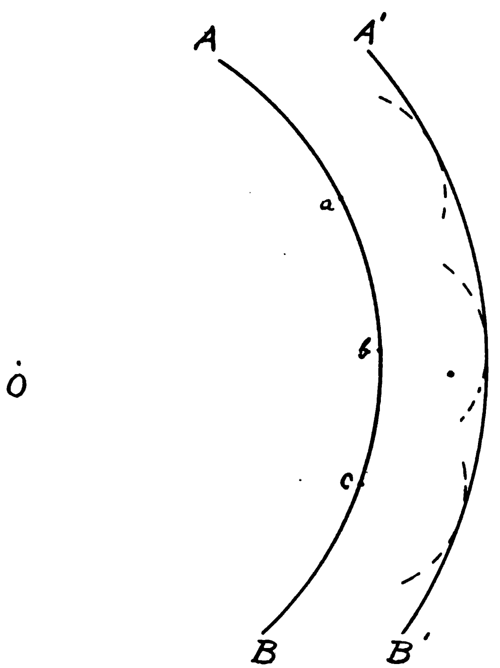


Figure 1

An instant previous to this the end A was at A'', say, and during the time of passage of the rod from A'' to A sound had traveled a distance $A''C''$. The wave front has then assumed the direction $AC'C''$. With uniform velocity of the rod in a homogeneous medium it will be seen from the geometry of the figure that $AC'\,C''$ is a

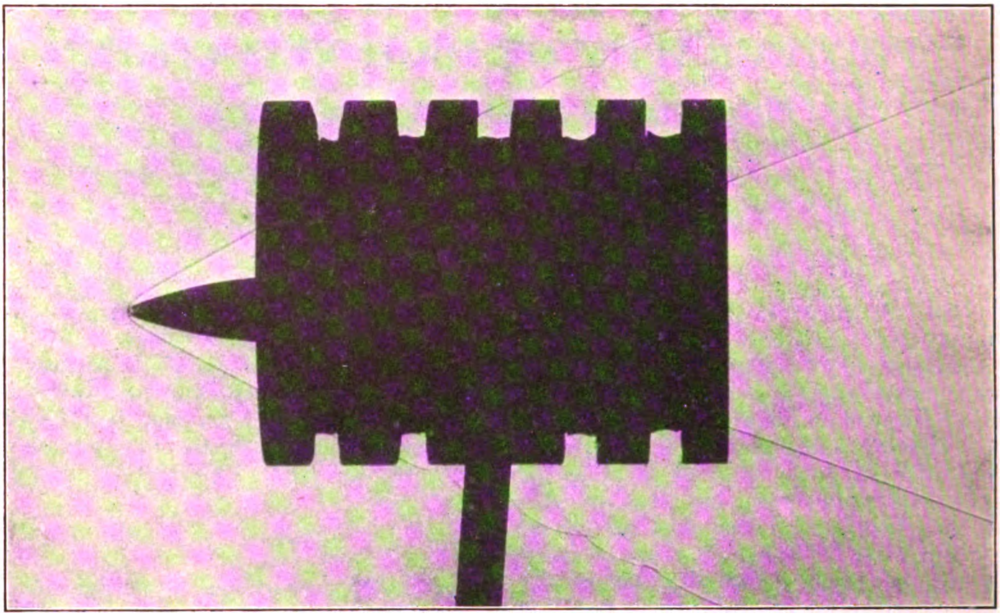


Figure 2

straight line. This illustration does not apply where the velocity of the rod—or disturbance—is less that the velocity of sound in the medium, for in that case the disturbance travels away faster than it is made. From the figure it is seen that the sine of the half angle $\alpha = \frac{S}{V}$, so that the velocity can be computed as $V = \frac{S}{\sin \alpha}$. In practice it is found that the head and tail waves are not parallel; the angle α is determined by a line lying between them.

Methods of obtaining this and similar photographs may be added here, partly to make the article complete and partly to serve as a suggestion for future research and application. Fig. 4 shows the apparatus for one method. *M* is a concave spherical mirror, *S* a spark gap, *C* a camera and *E* a sharp edge, all enclosed in a box or light tight room. The bullet passes through a spark gap *G*, enclosed, discharging a condenser circuit at the time, without, however, touching either terminal. The circuit, shown in Fig. 5, is arranged to give a definite time lag between the passage through *G* and the setting off of the photographing spark *S*. There are three oscillatory circuits, charged in parallel by a static machine at *G*. *L* is a variable inductance and *R* is a very high resistance, preferable a tube of slightly salted water. *R* permits

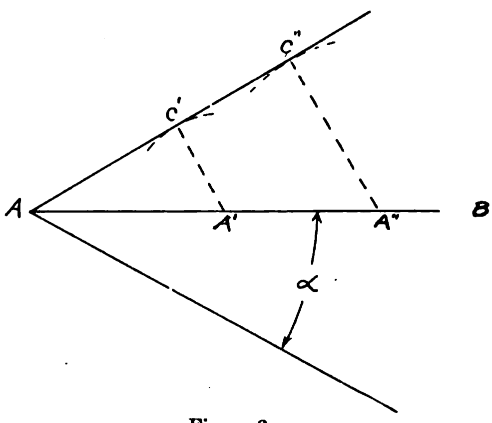


Figure 3

the charging up of C_3 and prevents its discharge except at the proper time through *S*. The circuits are all made up of short thick copper wire. The period of *I* is shorter than that of *II* and by strong

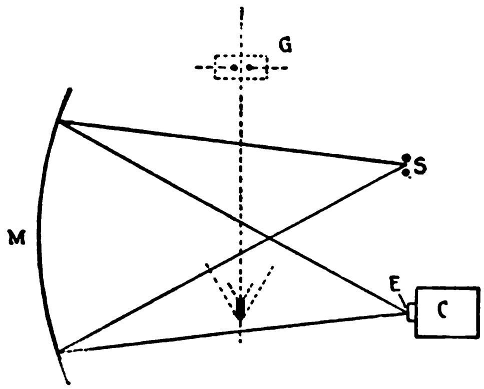


Figure 4

damping I can be made to discharge before II begins. There results a high difference of potential between m and n and the voltage across S rises. With a proper length of gap S circuit III will discharge when II has made one half oscillation, which can be varied at L. In practice a "time lag" of 1/2000 second has been found satisfactory.

Another method, not so precise as to locating the bullet at the time of photographing, is shown in Fig. 6. C_1 is a large and C_2 a small condenser, S the photographing spark gap, R a high resistance, T a tube connected to a ring through which the bullet passes, F a gas flame and D a disk with a hole in it. As the bullet passes through the ring a wave traverses the tube and blows the ionized gas through the hole in the disk to the other terminal, thus "triggering" off the spark at S. The small condenser C_2 is discharged but the resistance R prevents the discharge of C_1 until the difference of potential at S is great enough to break down the gap. The camera used in the above experiments was fitted with a lens working at $F/3.5$ and the mirror was about 12″ in diameter. The results are singularly beautiful as may be seen from Fig. 7, which is a photograph of a German bullet at about 2,700 feet per second. A faint idea of the variation in intensity of the wave front may be obtained by the way the wave shades off. It is rather surprising, too, that such a well defined tail wave is found. The "wake," at the rear, is not smoke, since this method of photography shows the variations in the refractive index of the air. Besides, the smoke is prevented from entering the box. It is probably due to the vortex motion of the air rushing in to fill the vacuum, for it has been calculated that there is a vacuum just at the base at these velocities. During this process the air is heated and great changes in density take place. These eddies broaden out considerably within the limits of the picture.

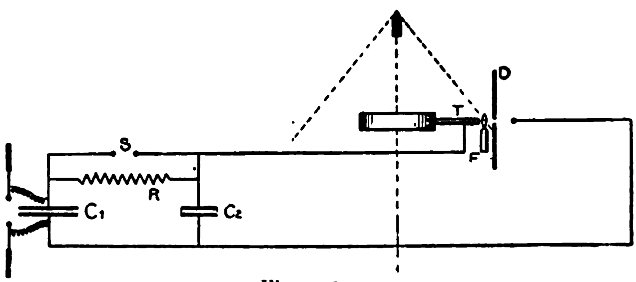


Figure 6

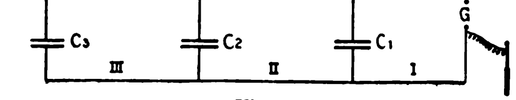


Figure 5

The apparatus previously described is expensive and difficult to obtain; similar results, not so perfect in detail, may be secured as follows. Fig. 8 was taken without a camera and with commercial dry plates. It is a special bullet, 0″.300 caliber, velocity 2,100 feet per second. There is a hole through it axially and a copper disk was fitted to the base to prevent the powder blowing out through the hole. This disk is seen at the rear with its own head and tail waves and eddies. At the rear of the bullet is seen an unexpected set of waves showing that the air at that velocity does not flow through freely. Thus the bullet has as much resistance as a flat headed one and

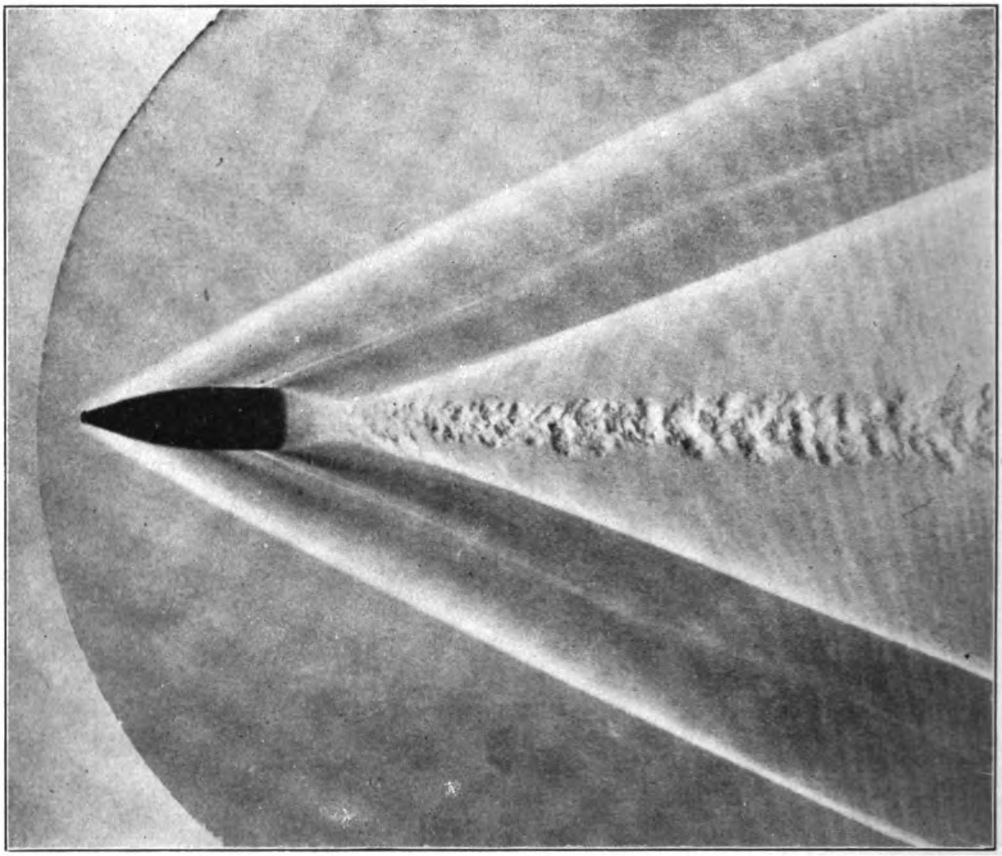


Figure 7

much less energy to overcome it as it has a smaller mass.

This photograph was taken with the apparatus shown in Fig. 9. B is a light tight box, hooded at the ends to prevent light through bullet holes from falling on the plate. S is the spark gap and w w the wires short-circuited by the bullet. The circuit is given in Fig. 10, and is due to C. V. Boys, of London. The lettering corresponds to that in previous diagrams. S' is an additional gap, enclosed, so that C_1 has to discharge through two gaps in series. The condensers are charged to the desired potential which is less than that required to jump both gaps in series. If one gap, S', can be short-circuited then C_1 will discharge through S, the photographing gap. This is accomplished by a secondary circuit through S', C_2 and G. When G is closed by the bullet, C_2 discharges through S' and hence C_1 through S. This is a "shadow method"; Fig. 2 is an example.

The preceding methods of showing air waves are surely refraction phenomena, as may be seen from Fig. 11. Let O be a point source of light—an electric spark—and PP a photographic plate. A section of the wave perpendicular to the axis would be represented by two circles. Light falling to K is unchanged in direction but a ray striking a region of greater density is deflected toward the normal on entering and away from it on leaving so that such a ray would take the course

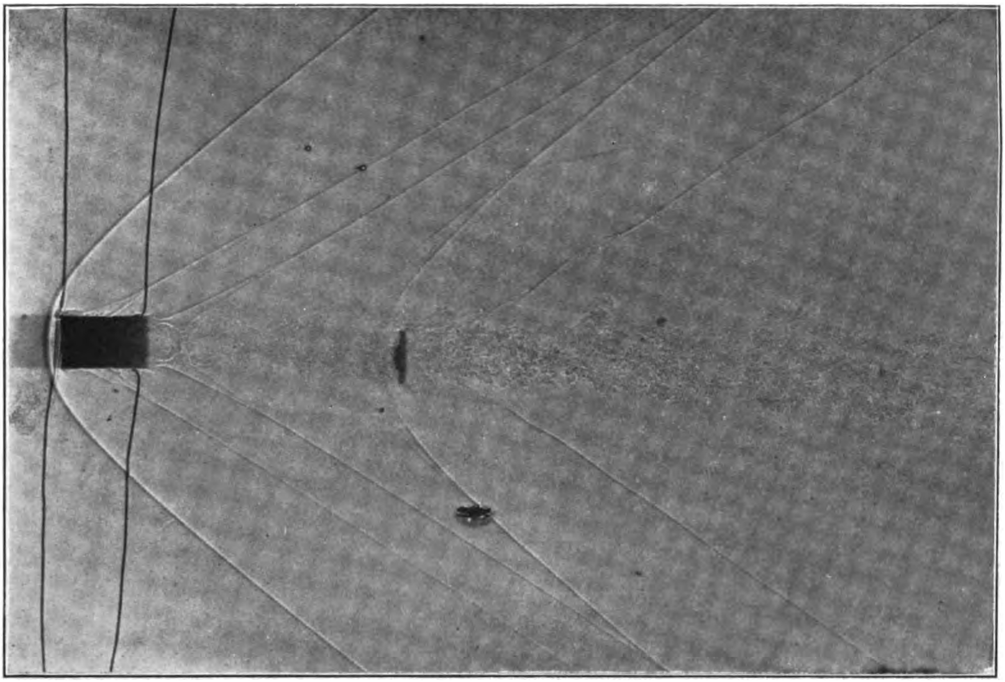


Figure 8

OM. Otherwise it would have arrived at R', so that there is an absence of light at M' and a cumulation at M.

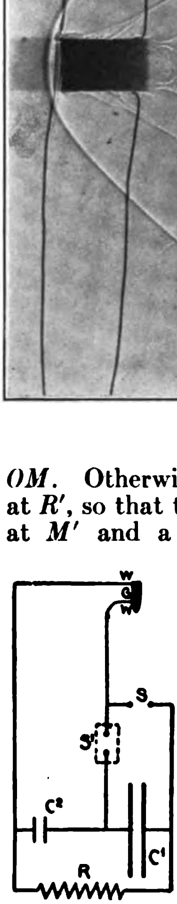


Figure 10

One is led to ask if application cannot be made to the useful arts and sciences, or in research or invention, of these powerful methods of analysis. In the case of the bullets, for instance, a movement of 1/100″ during exposure would show a blur on the negative. At 2,700 feet per second the time of exposure must be less than $\frac{1}{2700\times 12\times 100}=\frac{1}{3{,}240{,}000}$ second. Hence a study of phenomena at high velocity might find application of these methods. These may be studied "point by point," using large negatives and thus securing fine detail. In fact, the method of Fig. 9 gives enlargement; the writer has used it up to three diameters with success. It seems applicable to work on air or gases where the index of refraction can be utilized, and to a lesser degree, in liquids or crystals. A sound wave traveling longitudinally through a glass rod has been photographed velocity, 5,000 feet per second. A consideration of Fig. 11 shows that a point source of light is necessary; otherwise the well defined shadows will not be obtained. The range of the methods is surprising. The writer has used the scheme of Fig. 10 with great success with 20 feet between spark and plate. In this case the gaps were about 3/4″ long each and Cramer Crown and Hammer slow

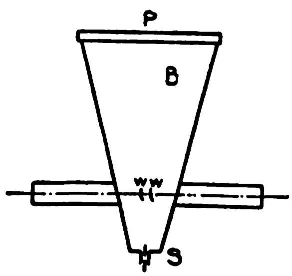


Figure 9

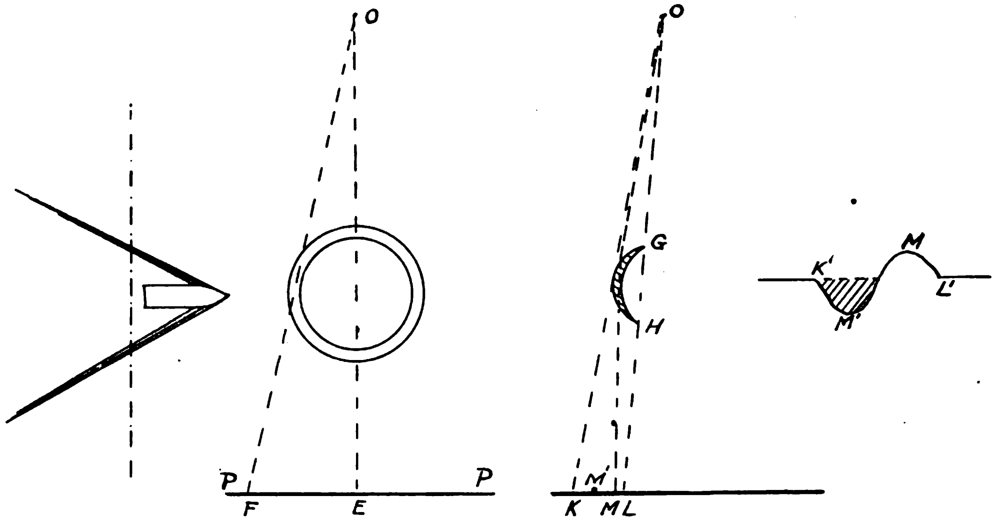


Figure 11

plates were used, 10 years old. The spark looked to be one half inch in diameter, but this is a physiological phenomenon as the pictures showed it to be virtually a point. One marvels that so much light can be concentrated in a point during so short an interval of time yet have enough actinic value to properly expose a photographic plate 20 feet away.

It is suggested that the formation and growth of crystals is a field where these methods might be applied with advantage. Theories regarding the birth of a crystal need confirmation; some of them have a bearing on the constitution of matter.

Nothing has been said about applying these ideas to a moving film; a great field is opened when apparatus is developed to do this conveniently. Bullets have been photographed at the rate of 92,200 per second, but little application has been made of the method in the arts. One would expect to get new ideas by using these methods stereoscopically, examining the pictures with a stereoscope and thus obtain space relations which cannot be gotten from single pictures.

The writer will be glad to coöperate with those desiring to make use of these ideas in the arts, feeling that such work would be truly constructive.

BEGINNINGS OF PHOTOGRAPHY

It is said that the action of light on fused silver chloride was used to make a photograph of the solar-spectrum by Scheele in 1777.

The first successful inquirer to secure permanent pictures through the influence of the sun's rays, seems to have been Nicephore Niepce, who in 1824 effected the progress of heliography by the use of a varnish made of asphaltum, or bitumen of Judea, applied to a highly polished metal plate or a glass plate, and developed by essential oil of lavender and white petroleum. The plate was exposed for several hours, the image etched, and then prints were made as from an ordinary etching.

The daguerreotype process consisted of exposing a polished silvered copper plate, fumed with iodine, in a camera a few minutes, developing the exposed plate with mercury vapor and fixing the image with hyposulphite. This complex process involved five distinct operations: cleaning and polishing the plate, coating the plate with sensitive ioduret of silver, adjusting and exposing the plate in the camera obscura, developing the invisible picture after the exposure, and removing the sensitive coating.

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